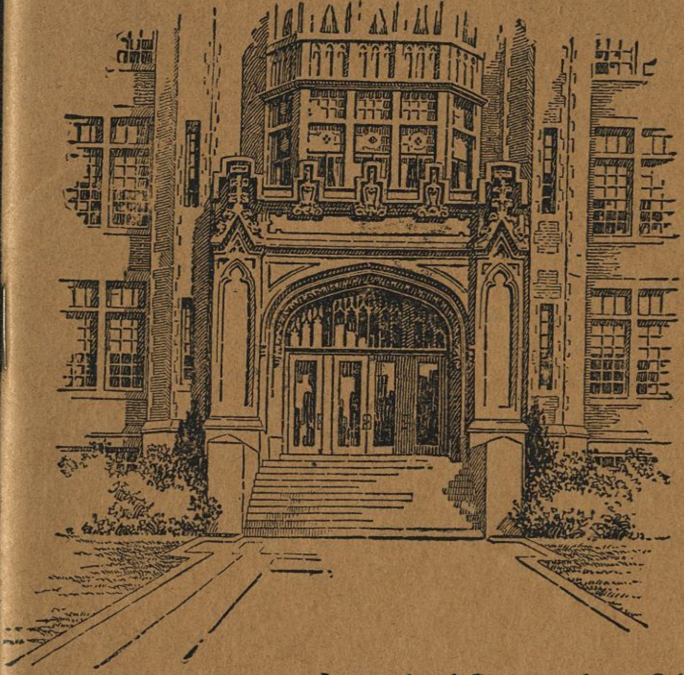

International Correspondence Schools
Scranton, Pa.

Cylinder, Guide, and Crosshead Repair Work

PREPARED ESPECIALLY FOR HOME STUDY

By
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APPRENTICE INSTRUCTOR

2502

EDITION 1

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CYLINDER, GUIDE, AND CROSSHEAD REPAIR WORK

Serial 2502 Edition 1

BACK SHOP REPAIRS

INTRODUCTION

1. In Fig. 1 are shown the parts that are to be considered in this Section. The parts here shown assembled comprise the cylinder, the cylinder heads, the cylinder bushing, the piston, the piston rod, the crosshead, the guides, the valve, the valve bushing, the valve-stem crosshead, and the back steam-chest cover. The guide yoke end is also shown. The arrangement as viewed from the rear is shown in Fig. 2.

Ordinary running repairs to these parts are made from time to time in the roundhouse. However, when the locomotive has made its required mileage, it is sent to the back shop for general overhauling and all these parts are put in first-class condition. If possible, the old parts are used; if not, new ones are substituted. The crossheads may be repaired or renewed, and this also applies to the pistons, the piston rods, and the guides.

In the roundhouse, only the part or parts to be repaired are removed; in the back shop, the locomotive is stripped of all the parts just named, as well as of any other parts that may have to be repaired at this shopping. The main rods are removed first, then the side rods are taken down. Next, the piston rods are separated from their crossheads, the front cylinder heads are removed, and the pistons are taken out. Finally, the crossheads are removed and the guides are taken down. The back cylinder head is not removed unless the joint requires to be ground in, or the cylinder is to be bored out to receive a bushing.

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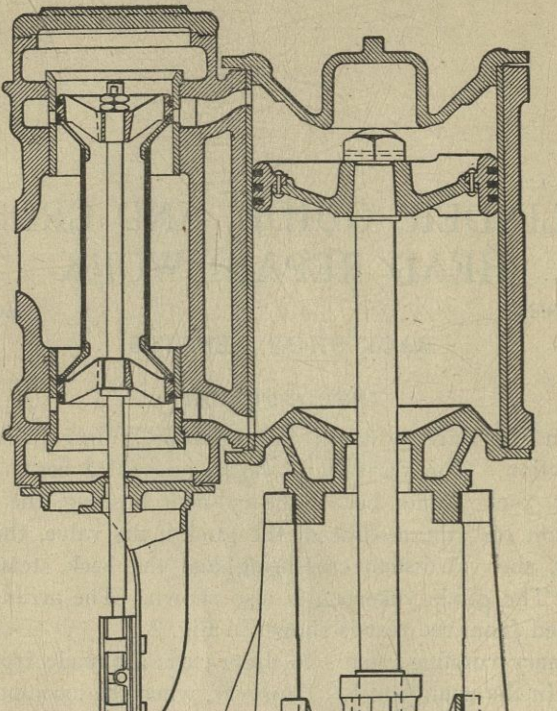


FIG. 1

As each part is taken down it is plainly stamped or marked with paint, and is then sent to the proper department of the machine shop for inspection and repairs. After all of the parts have been repaired, they are brought to the locomotive in the proper order for assembly. In the meantime, work is started on the cylinders by the men on the erecting floor.

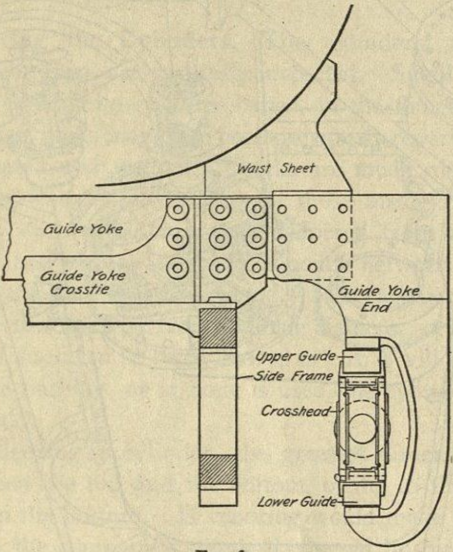


FIG. 2

CYLINDER WORK

2. Cylinder Bushings.—Some railroads apply a bushing to the cylinder when it is new, other roads keep boring the cylinder until it wears a certain amount oversize, usually about one-half inch, and then bore it out and apply a bushing thick enough to bring the cylinder back to its correct diameter. Bushings of cast iron or gun iron are always applied to cast-steel cylinders, because cast steel, owing to hard spots in it, cannot be finished as smoothly as cast iron. Cylinders with or without bushings are rebored if found to be $\frac{1}{16}$ inch or more out of round.

Cylinder bushings must also be removed if found to be loose owing to improper fitting during application. A loose bushing

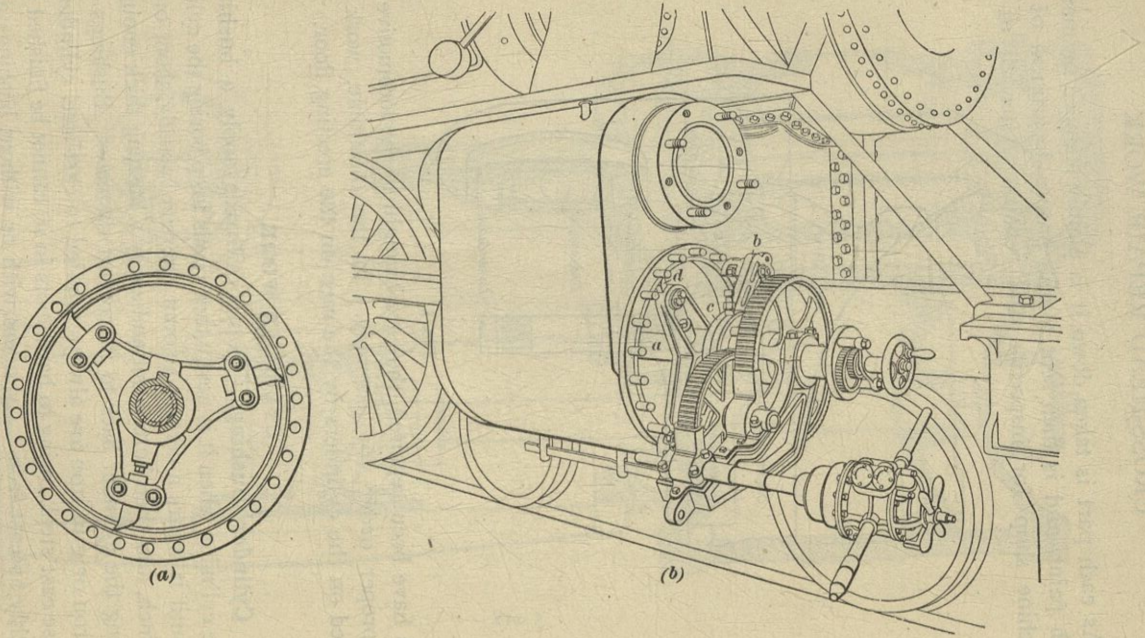


FIG. 3

can be detected by sound when tapped with a hammer. Steam may pass from one end of the cylinder to the other around the outside of the bushing when it is loose.

3. Reboring the Cylinders.—The cylinders, after being scraped and cleaned, are carefully inspected. Small cracks may have developed in the cylinder barrel, in the flanges or in the webs. Large cracks may have been previously reported and they must be located and welded. Cracks are much more liable to occur in cast-iron cylinders than in those made of cast steel. The bore of each cylinder is then calipered front and back at the quarters and also at intervals at points between the ends to see whether the bore is out of round. If a variation of $\frac{1}{16}$ inch or more is found to exist from the true diameter, or if the cylinder walls are found to be badly scored or cut, it will be necessary to rebore the bushing, or if none is used, the cylinder will have to be rebored.

When calipering a cylinder, the greatest dimension will be found between the top and the bottom, owing to the weight of the piston on the bottom. If reboring would make the bushing thinner than the company's standard, the old bushing will have to be chipped out and a new one applied. The bushing is about $\frac{3}{4}$ inch thick and it therefore can be rebored several times before renewal. When no bushing is used, and the diameter of the bore is at its maximum due to reboring at the various shoppings, the cylinder must then be bored for a bushing of sufficient thickness to bring it back to its standard diameter.

4. The apparatus shown in Fig. 3 (*b*) is used when boring out a bushing or a cylinder; a detail of the cutting tools is shown in (*a*). The boring bar *a* is set up in a central position in the cylinder and is held there by the support *b* and bearing *c*. To set the bar central, one of the tools *d* is rotated around the counterbore and the bar is shifted one way or the other until the tool point just touches all the way around. The other end of the boring bar is also made central in the same manner from the counterbore in that end. The piston does not come in contact with the counterbore, and it can therefore be assumed to be perfectly round, so that, when reboring, the original center of the cylinder bore will be preserved.

Some shops insert a bushing in the stuffingbox to support that end of the boring bar when the back cylinder head has not been removed.

No more material should be removed than is necessary to clean up the bore, and the final finish should be as smooth as possible so as to eliminate all tool marks. An attempt should be made to keep the bores of both cylinders the same size; the variation should not exceed $\frac{3}{16}$ inch.

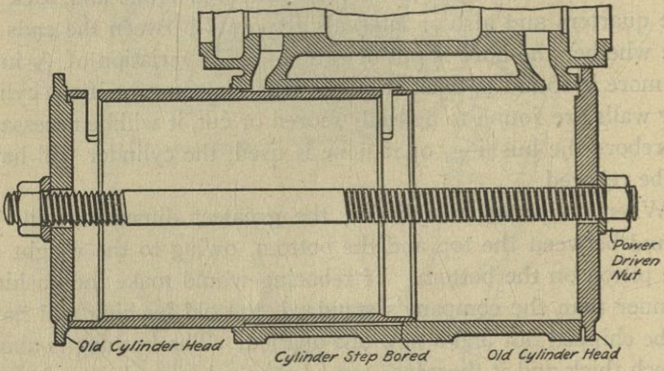


FIG. 4

If possible, the tool should be set to clean up the cylinder with one cut, because the time consumed in making a cut is considerable. The workman should bear in mind the largest dimension found in calipering or any unusually deep pockets and should set the tools accordingly. This precaution will obviate a second cut. If it should now happen that a small portion does not clean up, the fact will be indicated by a dark shiny surface when the bore is viewed from the end. In some cases this surface might clean up with the finishing cut, but as this cut is very light, it is probable that a second roughing cut will have to be made. A special device is sometimes used with which all three tools are properly set before the boring bar is set up. For example, No. 1 tool is set to bore the smallest diameter and just removes the skin and the oily surface, and the No. 2 tool is adjusted to increase the bore to a slightly larger size. The No. 3 tool is set and ground to give a nice finishing cut. The size to which the tools are set must be sufficient to clean up the cylinder.

5. It is the practice in some shops to step-bore the cylinder, Fig. 4, that is, the rear half of the cylinder is bored, say $\frac{1}{8}$ inch larger in diameter than the front half; the bushing is also turned accordingly. The bushing then enters the cylinder half way before the surfaces come metal to metal. This method permits the bushing to be entered at the rear end of the cylinder easily; also, there will be less tendency for the bushing to vary from a straight line when being pulled in.

Before the cylinders are rebored some railroads check their alinement with the frames. If found to be out of alinement, owing to stresses in service, the boring is done in such a manner as to make the required correction. The alinement is checked by passing a line through the cylinder and then centralizing it from the counterbores. The distance from this line to the frame is next measured at each end of the cylinder, and if the line is found to be closer to the frame at the rear than at the front, an effort is made to set the boring bar to correct this. Good judgment should be used in setting the bar rather than to try to estimate the setting.

In many cases a ridge or shoulder will be found in either the bushing or the bore near the end of the piston stroke owing to the ring not coming to the counterbore. Although such a ridge is objectionable, it is not necessary to rebore the bushing for this reason alone, if the bushing is found to caliper within the limits elsewhere. The ridge may be easily removed by chipping and filing.

6. Application of Bushing.—The cylinder bushing is pulled into position by means of the apparatus shown in Fig. 4. The port holes are already drilled but not chipped out, and the bushing is lined up so that the holes will coincide with the ports in the cylinder. Some roads turn the entire bushing to a diameter of about $\frac{3}{1000}$ inch larger than the bore of the cylinder, and the bushing therefore pulls in tight all of the way. Other roads turn the bushing to the same diameter as the cylinder; a bushing so fitted will also pull in tight. Also, the cylinder and the bushing may be step-bored as shown in Fig. 4 with the same variations in diameter on the surfaces in contact as already stated. In all cases the fit to be desired is such as not to impose severe strains on the cylinder wall but tight enough to prevent steam from passing between the bushing and the cylinder from one end of the cylinder to the other.

The ends of the screw are passed through the plate at the back end of the cylinder and also through the plate or an old cylinder head at the front end of the bushing. These heads or plates are prepared especially for this purpose. The nut is turned by an air-operated ratchet arrangement or by a train of gears with a ratio of about 30 to 1, operated by an air motor. The length of the bushing should be about $\frac{1}{16}$ to $\frac{1}{8}$ inch longer than the cylinder, and the projecting ends are faced off afterwards with a cylinder facing machine. Each cylinder head will then make a joint with the end of the bushing and the cylinder.

The outside of the bushing and the inside of the cylinder are coated with a lubricant of common oil before starting to pull the bushing in. After the bushing is applied the holes are drilled and tapped for the dowels used to keep the bushing from turning around the ports are then chipped out.

7. Some roads finish the bushings entirely before pulling them into place. Other roads turn the bushing to the correct size, but the bore is only roughed out and is finished after the bushing is drawn in. The reason is that the bushing may be distorted out of round when being pulled in and this condition can be remedied by boring out if the bore has been left rough before application. This practice is followed when the bushing has been pulled in unusually tight.

The bushing is counterbored for about 4 inches at each end so as to prevent a shoulder or ridge from forming at the end of the piston stroke. The counterbore also serves as a finished dimension to receive the projection on the cylinder head. The length of the main rod is adjusted so that only a part of a packing ring passes off the wearing surface into the counterbore, thereby preventing the formation of a shoulder. All of a ring cannot enter a counterbore because the piston would strike the cylinder head first. A counterbore carried so far in as to permit a packing ring to expand and stick would result in serious damage.

The inner end of the counterbore is beveled so as to facilitate the application of the piston.

8. **Removing Old Bushing.**—When removing an old bushing, a groove is first chipped through at the bottom from one end to the other and care should be taken that the wall of the cylinder is not damaged by the chisel. The bushing will collapse enough when cut through, so that it can be removed easily either by pushing it out or breaking it up. The two dowels that hold the bushing in place are removed first.

9. **Steam-Chest Bushings.**—The steam-chest bushings are examined and calipered in the same manner as the cylinder bushings, and are rebored or renewed as found necessary. The bushings should be removed if it is found that they will not clean up unless bored to about $\frac{1}{4}$ or $\frac{5}{16}$ inch more than their original diameter. They should be calipered on the bridges; for this reason the bushings have an equal number of bridges, so that one bridge is opposite another.

The apparatus used to bore the steam-chest bushings is similar to that employed to bore the cylinder bushings, except that a smaller spider is used, also the boring bar is smaller in diameter. Care should be taken to set up the bar central at the ends of the bushing where it is not worn, and just enough of the bushing should be removed to permit it to clean up. However, some roads require the bushings to be bored so that they will measure an even $\frac{1}{16}$, $\frac{1}{8}$, $\frac{3}{16}$, or $\frac{1}{4}$ inch oversize. This reduces the number of sizes of valve rings and bull rings that have to be carried in stock.

The bushing will have to be chipped out and a new one applied if it is found that further cleaning up will make the bushing too much oversize. When turning new bushings, the distance between the shoulder in the bore of the steam chest against which the bushing is pressed, and the end of the chest should be checked with the drawing. This distance may not be correct, owing to an error in machining. If any variation is found, the necessary correction can be made on the shoulder of the bushing. That is, if the steam chest is recessed in too far, the shoulder on the bushing is not turned down so far, but if the steam chest is not recessed far enough, the shoulder of the bushing is turned down farther.

The bushings are pulled into place by means of an apparatus similar to that used to pull in the cylinder bushings. The back bushing is pulled in first because it is more important to obtain the required dimension between the center of the steam chest and the back face than between this center and the front face. The reason is that no parts are attached to the front cover.

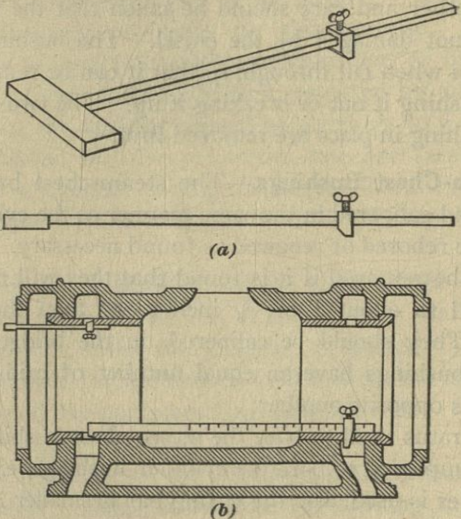


FIG. 5

As in the case of the cylinder bushings, some roads prefer to bore the bushings after application to insure that both are bored in line and that they are perfectly round. Other roads finish the bushings entirely before application.

10. Locating Steam Edges of Ports.—After the back bushing has been pulled in and the apparatus removed, the steam edges of the back ports are checked to see whether they are the specified distance from the back face of the steam chest. The gauge used is shown in Fig. 5 (*a*) and is shown applied at the top of the bushing in view (*b*). If it is found that the bushing is not the specified distance from the back face of the steam chest, an error has been made in locating and machining the shoulder on the bushing, or the recess in the steam chest against which the shoulder fits may not have been located correctly. The error may be corrected by pulling out the bushing and applying another that has been turned up correctly. Rather than to do this, it is the practice on most railroads to apply the front bushing in such a way as to obtain the specified port spacing and then alter the length of the valve rod when setting the valves. On other roads, if the bushing has been pulled in too far, the practice is to draw it back the amount required. A bushing that has been drawn back is not as tight as before, and the dowel may not hold it from working. The shoulder on the bushing should always be pulled up against the recess in the steam chest to insure it against moving in farther.

Unless a bushing is machined to fit its individual steam chest, it can hardly be expected to pull in to its correct position. The general practice is to requisition the bushings from stock, and slight variations may usually be expected. Generally, the workman who applies the bushings has nothing to do with the machining; he merely applies the bushings as received.

With the correct port spacing, and the back bushing in too far, a washer of the required thickness must be applied to the collar of the valve rod when the valves are being set, so as to bring the valve forwards on the rod the same amount as the bushing is misplaced. With the correct port spacing and the bushing not in far enough, the amount that it is out of its correct position must be turned off the collar when the valves are being set, so as to bring the valve back on the valve rod. The valve rod is said to be lengthened in the first instance and shortened in the second, but what really happens is that the position of the valve on the valve rod is changed. That an error in locating the back bushing can be corrected in the valve rod should not lead to carelessness in turning and applying the bushing.

11. The front bushing is applied next and the port spacing or the distance between the steam edges of its ports and the edges of the ports in the back bushing is checked by the gauge shown applied at the bottom, Fig. 5 (*b*). If the back bushing is assumed to be located correctly and the port spacing does not check with the drawing because of an error in the front bushing, the error can be corrected when assembling the valve, by making the valve spool to suit the spacing of the ports. If the spacing is too much, a valve spool this much longer will be required; if the spacing is not enough, a valve spool this much shorter will be necessary. A small amount, such as $\frac{1}{16}$ inch, can be machined off one end of the spool unless both ends of it appear rough, but a large amount, such as $\frac{1}{4}$ inch or $\frac{1}{2}$ inch, would require that half the amount be taken off each end. Altering the spool is probably preferable to pulling out the bushing and applying another, but the importance of maintaining standards cannot be emphasized too strongly. When the proper care is taken, all dimensions will check exactly with the drawings.

The foregoing may be summarized as follows: An error in locating the back bushing, if the port spacing is correct, requires a change in the length of the valve rod; an error in the spacing due to a misplaced front bushing involves a change in the length of the spool from standard; an error in the back bushing and the spacing requires a change in both the valve rod and the spool. If both bushings are in wrong and the spacing is still correct, a change in the valve rod alone is necessary.

With the bushings in place the dowels used to secure them are renewed and, although it might seem that the bushings when pressed in and doweled could not move, yet the distance between ports will almost always be found to be greater between shoppings.

The steam-chest bushings may be turned to the same size as the bore of the steam chest or they may be from one-thousandth to two-thousandth inch larger.

Great care must be taken not to damage the bridges when pulling in the bushings. Even though the bridges between the ports in the bushings are relieved or turned smaller, they are liable to crack under too much stress.

Most roads have facilities for casting their own bushings of ordinary gray iron, but rough castings of a much better quality can be purchased from manufacturers who specialize in castings of this nature.

CYLINDER-HEAD WORK

12. **Grinding In of the Heads.**—Either cylinder head may have to be renewed or, if it is leaking badly, the joint or the end of the cylinder against which the head rests, will have to be repaired and the head ground in. Slight leaks can be stopped by merely grinding in the head alone.

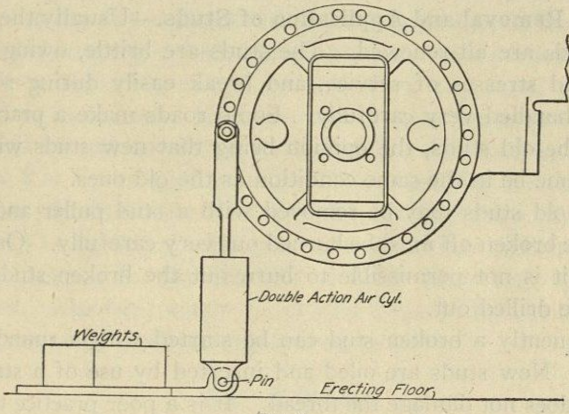


FIG. 6

A scored joint can be repaired in either one of two ways: the end of the cylinder can be refaced but this method is objectionable and should not be used unless the joint is very bad, because it shortens the cylinder. A quicker and a cheaper method is to drill one, two, or three small holes in the end of the cylinder where the leak has cut a channel, and insert copper plugs. These are screwed in as far as possible and then sawed off so as to leave about $\frac{1}{32}$ inch projecting. The projecting ends are riveted over carefully and the excess is removed with a file. A coarse grade of carborundum and oil is next applied to the joint, the head is applied and held against the face of the cylinder by means of a long rod and a spring. The rod is passed through the cylinder and is secured at the other end so that the compression of the spring is just sufficient to keep a little pressure on the joint being ground.

The grinding apparatus shown in Fig. 6 is then started and the grinding is continued until inspection of the joint shows that it is in good condition all the way around. A smoother joint can be obtained by using finer carborundum, and a good polish can be obtained by the application of oil alone. The joint must be kept well supplied with oil when grinding. When finished, the joint is washed off with gasoline to remove emery and then coated with a good grade of oil.

13. **Removal and Application of Studs.**—Usually the cylinder studs are all renewed. The studs are brittle, owing to the heat and stresses of service, and break easily during removal unless handled very carefully. Some roads make a practice of using the old studs, the opinion being that new studs will in a short time be in the same condition as the old ones.

The old studs may be removed with a stud puller and those that are broken off must be burned out very carefully. On roads where it is not permissible to burn out the broken studs, they must be drilled out.

Frequently a broken stud can be started with a round-nosed chisel. New studs are oiled and inserted by use of a stud nut, which does not damage the thread. It is a poor practice to use a Stilson wrench on a stud. The continual removal of broken studs results in the hole becoming too large. Some shops tap out the hole $\frac{1}{8}$ inch larger and apply a step stud, so that the part that passes through the cylinder head is smaller by this amount. Other roads enlarge the hole to a **V** shape and build it up by welding. This requires the cylinder joint to be refaced. The welding is done before a new bushing is applied so that only one refacing is necessary.

A weakening groove about $\frac{1}{4}$ inch wide and $\frac{1}{8}$ inch deep is usually turned on the front cylinder head studs near the inner end of the outer thread. This weakens the studs below the holding power of the threads on their outer ends and serves to prevent a part of the cylinder wall from being carried off with the head should it be knocked or blown out. The reason why the part of the stud next to the outer thread is nicked is that enough of the stud will be left if breakage occurs to permit of removal with a stud puller. The back cylinder head is not often damaged, hence it is not customary to nick these studs. A weakening groove is sometimes cut in the cylinder head instead.

14. Applying Back Cylinder Head.—The back cylinder head is one of the first parts to be applied. It is lifted up to the proper height by a crane, and is guided over the studs and partially entered into the counterbore of the cylinder before the crane is released. Care must be taken that the joint is clean, then a coating of oil should be applied to protect it from rust. Some roads employ a thick black varnish for this purpose. The threads on the studs should be well oiled, and faced nuts are applied on each stud. Each nut is run on as far as possible by hand and the nuts on the quarters are then tightened up slightly with an **S** or a gooseneck wrench. The remaining nuts are then tightened; finally all the nuts are tightened gradually, care being taken not to tighten up one nut too much before tightening the ones adjacent. In this manner a good steam-tight joint is obtained. The head might be ground in perfectly but it would not be steam-tight unless tightened up properly.

GUIDE WORK

15. Purpose.—The purpose of the guides is to compel the crosshead to move in a straight line with the axis of the cylinder. The arrangement of the guides depends on the type of crosshead used. Two guides are used with the alligator and Laird types of crossheads. With the former type, one guide is above the center line of the cylinder, and the other one is below it; with the latter type both guides are above the center line of the cylinder. The guide used with the Dean type of crosshead described farther on comprises a single bar made up of three parts.

The front ends of the guides are bolted to lugs on the back cylinder head; their rear portions are secured rigidly to the frame by means of the guide-yoke end and the guide yoke. The

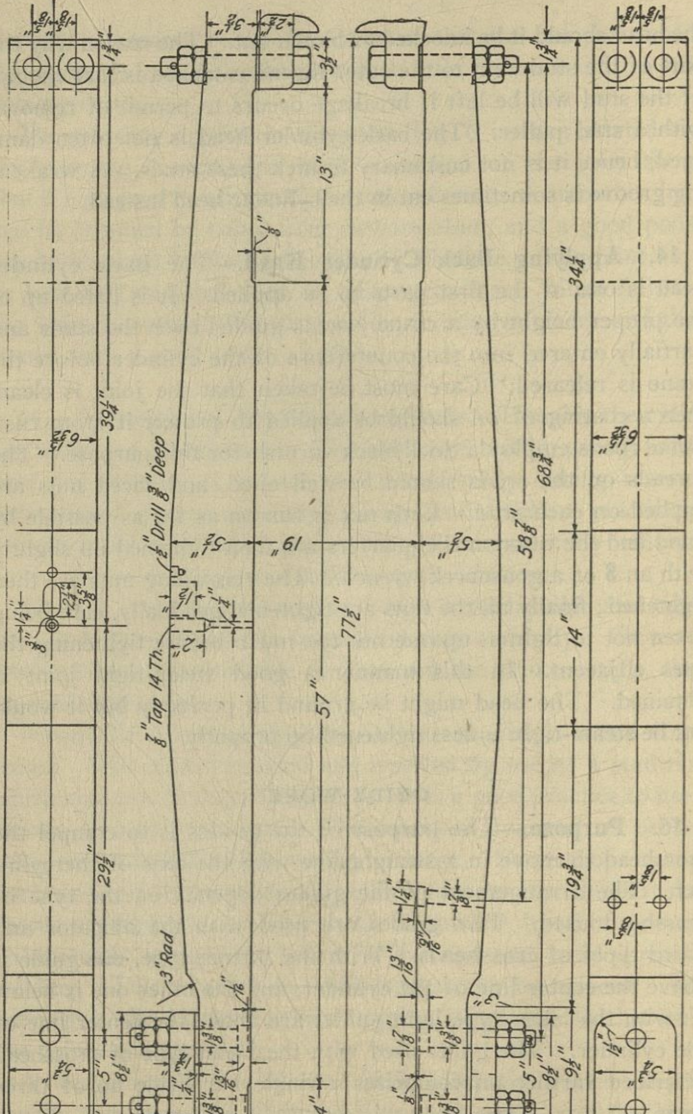

7/8" Tap 14 Th.
7/8" Drill 3/8" Deep
3" Rad
77 1/2"
57"
19"
13"
14"
34 1/4"
68 3/4"
58 7/8"
39 1/4"
29 1/2"
19 3/4"
9 1/2"
8 1/2"
5 3/4"
5 1/2"
5"
4"
3 1/2"
3 1/4"
2"
1 1/4"
6 15/32"

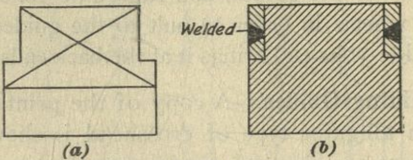
FIG. 7

point where the guides are bolted to the guide-yoke end depends on the type of engine truck. With a four-wheel truck, the front driving wheels are so far back that the guides can be reached only by bringing the guide yoke and the guide-yoke end in front of these wheels; this brings the guide-yoke end about midway of the guides. With a two-wheel truck, the front driving wheels are directly inside the guides, and the guide yoke has to be set behind these wheels in order to bolt to the guides. This position of the guide-yoke end brings it at the back ends of the guides.

16. Machining Guides.—A copy of the print of the guides used with an alligator type of crosshead is shown in Fig. 7. Both guide bars are identical, except that the top one has an oil hole and the bottom one has not. Guides are forged, that is, they are drawn out in the smith shop from billets of good quality steel and are finished all over on the planer, or miller, except on their horizontal wearing surfaces that are left with about $\frac{1}{32}$ inch excess material. These surfaces are finished on a grinding machine, as it gives a smoother surface than a planer. The direct wearing surfaces are relieved $\frac{1}{8}$ inch at a point 13 inches from the front, and at a point 4 inches from the back. This prevents the crosshead from wearing a shoulder on the guides at the end of its stroke. Also, the additional 13 inches in the length of the guide permits the piston to be moved out of the cylinder without disconnecting the piston rod from the crosshead, when applying new rings.

17. Repairing Old Guides.—When the old guides are removed they should be checked with a straightedge on the faces and sides. The guides may be found to be bent and, if so, they will have to be sent to the smith shop for straightening. If the faces are worn, they must be planed or ground unless worn to the limit.

The crosshead wears against the top guide with the locomotive moving forwards and against the bottom guide with the locomotive moving backwards. In addition to the wear on the part of the guide in direct contact with the crosshead, the sides of the guide also wear because of the side motion and thrust of the crosshead. The sides of the guides when worn are trued up on the planer or miller to the shape shown in the end view, Fig. 8 (*a*). When the width has been reduced to about ¾ inch, by wear and truing up, the practice in some shops is to fit and weld a liner on the sides as shown in the section in view (*b*); other shops restore the guide to standard size by electric welding. The guide is then planed and brought back to the standard width. The liners may again be renewed from time to time as they wear down and are again machined. When reconditioning guides, both must be made the same width, and all recesses the same depth.



(*a*) (*b*)

Fig. 8

After the sides have been planed, the direct wearing surfaces are made smooth and true by grinding. As much as ⅛ inch may be removed by grinding in a very short time, and it is then seldom necessary to clean up this surface on a planer. It will be found that the edges of the guides show the greatest amount of wear and they are generally rounded off; formerly, the practice was to maintain the edges sharp.

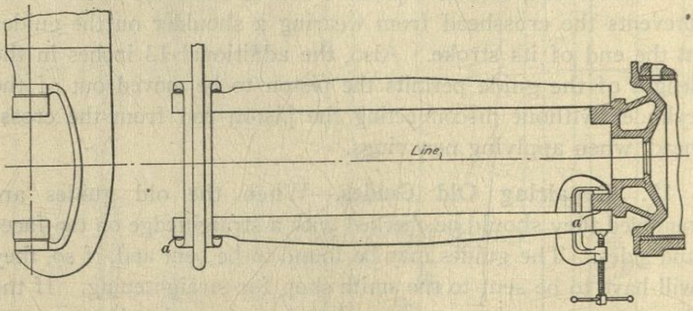
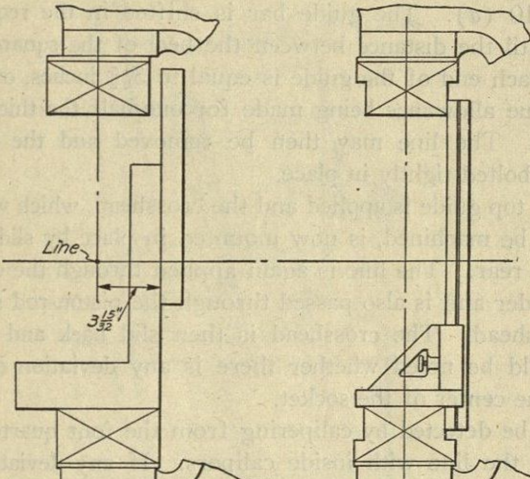


Fig. 9

18. Lining Up the Guides.—The term *lining up the guides* refers to the work of setting their main wearing surfaces parallel to the cylinder axis, and also their vertical center lines in line with this axis. See Fig. 9. When lining up the guides, the cylinder axis is prolonged to the rear of the cylinder by passing a line through its center.

There are several methods of doing the work; the lining up of the guides used with an alligator crosshead will be explained first. The first step is to place the lower, or bottom, guide in its approximate correct position, that is, with the front end suspended from the lug on the cylinder head by a loose-fitted bolt or **C** clamp, and the other end resting on its seat on the guide-yoke end. The guide bar is now brought the specified distance, or 9½ inches in this case, from a line that has been previously passed through the cylinder and made central of the cylinder at the front and of the stuffingbox at the rear. The line must be extended back several feet beyond the ends of the guides and must be pulled taut; the line then becomes an extension of the cylinder axis.



(a) (b)

FIG. 10

19. To place the guide at the proper height, a pair of inside calipers is set to 9$\frac{1}{2}$ inches, and a test is made between the line at the front and the rear of the bar. Then the guide is adjusted by applying or removing liners at the ends at *a*, Fig. 9. The guide is now parallel to the line and hence to the cylinder axis.

To bring the vertical center line of the guide in line with the line, or string, and hence with the cylinder axis, a small square is applied on the top of the guide and the heel is lined up with the edge, Fig. 10 (*a*). The guide bar is shifted in the required direction until the distance between the heel of the square and the line at each end of the guide is equal to 3$\frac{15}{32}$ inches, or half its width, due allowance being made for one-half the thickness of the line. The line may then be removed and the guide clamped or bolted tightly in place.

Next, the top guide is applied and the crosshead, which will be assumed to be machined, is now mounted in place by sliding it in from the rear. The line is again applied through the center of the cylinder and is also passed through the piston-rod socket in the crosshead. The crosshead is then slid back and forth and it should be noted whether there is any deviation of the line from the center of the socket.

This can be detected by calipering from the four quarters of the bore to the line with inside calipers. If any deviation is noted, it indicates that the bottom guide was not properly lined up and must be corrected. With the lower guide properly set, the top guide is lined down until it is $\frac{1}{32}$ inch from the crosshead; this can be determined by inserting a feeler between them at the front and the rear. Then with the top guide clamped securely, the crosshead is moved to and fro; if it sticks or binds, the upper guide must be moved in the proper direction to allow for sufficient lateral play, or about $\frac{1}{32}$ inch. The direction in which the guide is to shifted can be determined by inserting a feeler. The top guide is therefore lined up with respect to the bottom guide by using the crosshead.

20. Another Method.—Another method of lining up the guides is to line up the bottom guide as already described, and then set the top guide the specified distance from it plus the

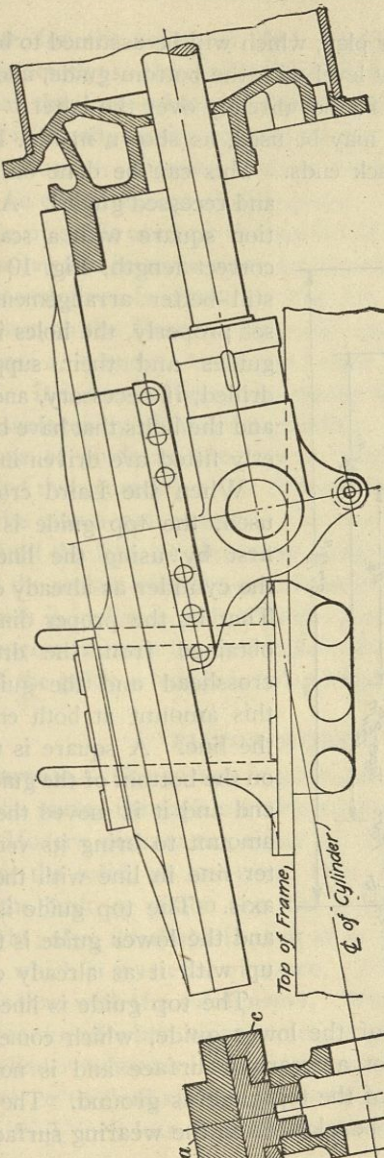


FIG. 11

amount necessary for play, which will be assumed to be $\frac{1}{32}$ inch. The top guide is now level with the bottom guide, and the next step is to line up the former directly over the latter. To do so, a square and a scale may be used, as shown in Fig. 10 (*a*), at the front and the back ends. This can be done on both new and recessed guides. A combination square with a scale of the correct length, Fig. 10 (*b*), is a still better arrangement. When set properly, the holes in the top guides and their supports are drilled, if necessary, and reamed, and the bolts that have been properly fitted are driven in.

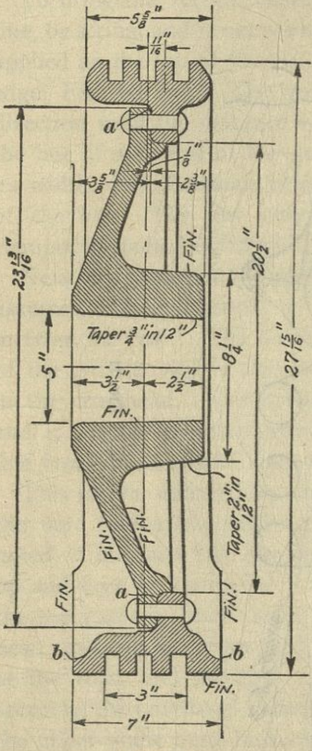


Fig. 12

When the Laird crosshead is used, the top guide is lined up first by using the line through the cylinder as already explained. That is, the proper dimension is obtained from the drawing or crosshead and the guide is set this amount at both ends above the line. A square is then used on the bottom of the guide at each end and it is moved the required amount to bring its vertical center line in line with the cylinder axis. The top guide is clamped and the lower guide is then lined up with it as already explained. The top guide is lined up first because the bottom of the lower guide, which comes directly above the line, is not a wearing surface and is not ground, whereas the bottom of the top guide is ground. The measurements should always be taken from the wearing surfaces.

21. Formerly it was the practice to close the guides by varying the thickness of the liners under their ends, and thereby compensate for the wear of the crosshead. However, with modern locomotives, the guides are so heavy and difficult to handle that they are seldom disturbed once they are bolted in place. It is usually easier to take up the wear by relining the crosshead shoes or slippers. Many roads do not permit the guides to be closed except at shoppings.

The type of guide used on the inside cylinder of a three-cylinder locomotive and in some cases on the outside cylinder of two-cylinder locomotives is shown in Fig. 11. This guide is commonly known as the Dean or three-bar type, because it is made of three bars *a, b,* and *c,* which are bolted together to make one solid part. It is reconditioned by taking it apart and truing up the worn surfaces by planing or grinding.

This type of guide is lined up by placing the crosshead in position and then running a line through the center of the cylinder and the piston-rod socket in the crosshead. The guide is then set until the line, as shown by using inside calipers, comes central of the socket with the crosshead in any position.

The guide is inclined with a three-cylinder locomotive, hence some arrangement must be used to keep the crosshead from sliding out of the guide when it is being lined up.

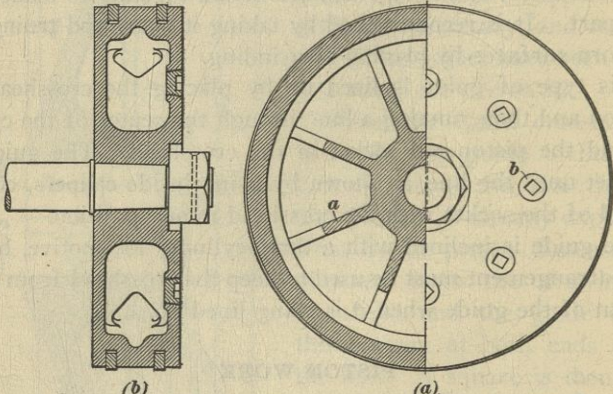
PISTON WORK

22. **Purpose.**—The piston is provided to transmit the pressure of the steam through suitable connections to the driving wheels. Modern pistons are either of the **I**, or built-up, type, Fig. 12, or the solid, or one-piece, type, Fig. 13. The advantages of the built-up piston are that it has great strength and light weight; also, its shape is such as to cut down the cylinder clearance, which is wasteful of steam. The expense of renewal is also less than with the solid piston. With this type, the piston has to be scrapped when worn, unless it can be turned up for a smaller cylinder, whereas it is only necessary to renew the wearing surface, or the bull ring, of the built-up piston. Pistons are turned $\frac{1}{32}$ to $\frac{1}{16}$ inch less than the diameter of the cylinder.

23. **Description.**—The built-up piston, Fig. 12, consists of a cast-iron or a gun-iron bull ring, riveted to a central steel

spider. The bottom surface of the bull ring, or the part that bears directly on the cylinder, is made wider so as to spread the wear over a greater area and thereby lessen the effect of wear on the diameter of the piston. The upper portion of the bull ring is narrower than the lower portion, and the edges are beveled; the reason is to prevent the steam ports in the bushing from being partly closed with the piston at either end of its stroke.

The solid piston is cast in one piece and its interior is cored out to reduce the weight. The walls, after being machined, should be about 1 inch thick. The cored-out sections are separated by webs *a* that resemble spokes, and the cores are removed through the holes closed by the plugs *b*. These holes are drilled, tapped, and fitted with plugs that are prevented from turning out by dowels. Some roads drill holes through the opposite walls and insert staybolts to strengthen the piston.



(*b*) (*a*).

FIG. 13

24. Machining New Bull Ring.—The bull ring wears most on the bottom, hence the greatest diameter of the piston after being in service will be horizontal. As much as $\frac{1}{8}$ inch or more may have to be removed when truing up the piston, and this would make it much too small unless the cylinder bushing is to be renewed. Therefore, in the back shop the old bull ring is generally removed from the spider and a new one is applied. The worn bull rings are cleaned up and then laid aside for use in smaller cylinders. However, if the piston is out of a small cylinder, the bull ring is scrapped.

The work of machining a new bull ring may be done on either the boring mill or the lathe, but the former is preferable. The ring is gripped by the dogs of the table and is packed up level by trying the tool or pointer on the surface *a,* Fig. 12, to be finished. Next, the outside of the ring is made concentric with the table by applying a pointer on the outside, and the dogs are then tightened up. The surfaces marked *fin* are now machined and the outside surface is turned $\frac{1}{32}$ to $\frac{1}{16}$ inch smaller than the diameter of the cylinder, although some roads allow more than this. The face *a* in contact with the steel spider is faced to a point $3\frac{5}{8}$ inches below the upper surface *b*. When the bull ring is turned over, the wearing surface is finished until it is 7 inches wide. The ring is bored to an internal diameter of $23\frac{13}{16}$ inches at one point and $20\frac{1}{2}$ inches at another point.

The center-ring groove is located midway between the surfaces *b*. The slots are $\frac{3}{4}$ inch wide and 1 inch deep, and the grooves are spaced $\frac{3}{4}$ inch apart.

Sometimes the wearing surface is so wide as to cover the cylinder-cock holes. In such cases the bull ring has a cut in on each side a **V** to keep the holes open.

Before applying the bull ring, the spider should be examined for cracks around the rivet holes and also for any damage that may have occurred during the removal of the old bull ring and the piston rod.

After a worn bull ring is removed from the spider, the circumference is trued up and the ring grooves are examined for wear. If found slightly worn, they are squared up by cleaning up the sides with the tool. However, if it is found that the slots are already too wide, and the use of oversize rings is not permitted, then the ring is no longer of any use.

25. Solid Piston.—As already explained, a solid piston when worn is discarded and a new one is machined. The piston is set up on the boring mill in the same way as is the bull ring, with the largest opening of the piston-rod fit uppermost. One head is fed across the top and the other one is started down the side. Then the head that is to do the boring is set at an angle to bore the piston-rod fit to a taper of $\frac{3}{4}$ inch per foot and to the diameter of the rod. If the piston is to be applied to a piston rod already turned, then the size is taken from a corresponding point on the rod. It is important that the piston make a tight fit on the rod, therefore the necessary care must be taken in boring out the head. Finally, the ring grooves are turned in the piston.

After the finishing cuts have been made, the piston is turned over on its finished surface and secured level and concentric. The piston is then machined to the required thickness, and the bore is countersunk for the piston-rod nut.

The piston is next sent to the drill press, where the holes are drilled and the plugs are fitted or the staybolts applied.

Some roads do not turn the pistons or bull rings on the outside until the piston rod has been applied to the piston or the spider. The piston and the rod are then set up in a lathe on the piston-rod centers, and turned, thereby insuring that the bull ring or piston is concentric with the piston rod.

26. Machining a New Spider.—A new spider when being machined is placed on the boring-mill level and concentric, with the boss down, and is bored out in practically the same manner as a solid piston. The taper of the piston-rod fit is $\frac{3}{4}$ inch in 12 inches, Fig. 12, and the bore is 5 inches at the largest diameter. The outside of the spider is turned to a diameter of $23\frac{13}{16}$ inches and the top is faced at an angle of $22\frac{1}{2}°$. The spider is now inverted, leveled, and made concentric and the other surfaces are machined. Great care must be taken in machining the surface that comes against the bull ring to a point $3\frac{5}{8}$ inches from the face of the spider. A dimension in excess of this will alter the combined length of the piston and the rod. The other surfaces are machined to the size shown on the print.

PISTON-ROD WORK

27. Manufacture.—The piston rod, Fig. 14, which connects the piston to the crosshead is subjected to hard service because it has to withstand the alternate pull and push of the piston. At high speeds the change in the stresses occurs very rapidly, therefore special care is taken in the quality of the steel that is used in the rod and also in its manufacture. The piston rod is forged from a billet of steel to a diameter of about one-half inch larger than necessary so as to allow for finishing. The rod is forged instead of being cast, because forging not only gives a finer and more even structure to the metal but also removes any seams, cracks, or blowholes, that might be found if cast. Rods, axles, and crankpins are forged for the same reason. Finally, to insure that all internal stresses are removed, the piston rod is heat-treated. This is done as follows: The rod is heated in a furnace to a temperature of 1,600° to 1,650° and is kept there for 1 hour for each inch in thickness. It is then cooled in the open still air; next it is placed in the furnace and the temperature is run up to 1,200° to 1,250° and kept there for a length of time depending on the thickness of the rod. It is then allowed to cool in the furnace.

The piston rod and the guide bars are made longer on some locomotives so as to reduce the length of the main rod. The length of the main rod becomes excessive with modern locomotives when the driving wheels are of large diameter.

In order to reduce the weight, hollow piston rods are used on some roads. They are made by first boring out the rod and then drawing down the ends by forging. Piston rods are connected to the crosshead by either a key or a nut, depending on the design.

28. Finishing of Piston Rod.—At the ends, the piston rod has a tapered fit in the piston and the crosshead. The fit, which is made by turning or grinding, must be such that the tapered ends will fit tight all over in the piston and the crosshead when they are drawn up against the collars on the rod. Between the ends, the portion of the rod that operates through the packing is finished true and smooth. With such a finish, the wear on the

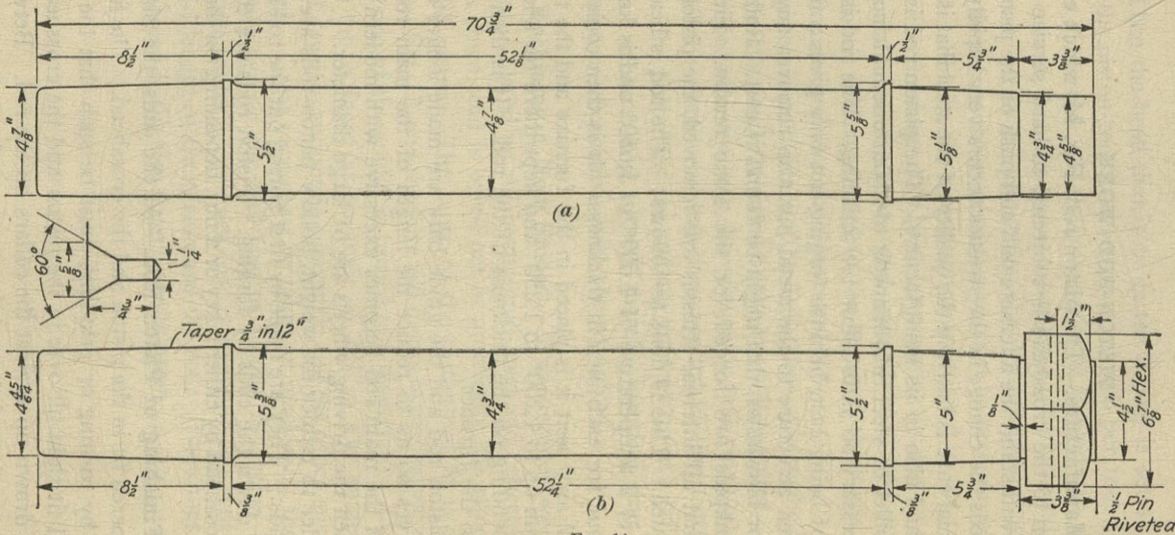

70 3/4"
8 1/2"
1/2"
52 1/8"
1/2"
5 3/4"
3 3/8"
4 7/8"
5 1/2"
4 7/8"
5 5/8"
5 1/8"
4 3/4"
4 5/8"
(a)
60°
5/8"
3/4"
1/4"
Taper 3/4" in 12"
4 45/64
5 3/8"
4 3/4"
5 1/2"
5"
1/8"
1 1/2"
4 1/2"
7/8" Hex.
6 7/8
8 1/2"
3/8"
52 1/4"
3/8"
5 3/4"
3 3/8"
1/2 Pin Riveted.
(b)

FIG. 14

packing is reduced and it remains steam-tight longer. The smoothest surface is obtained by grinding, but a good surface can also be obtained by rolling if a grinding machine is not available.

In Fig. 14 (*a*) are shown the dimensions to which the forging should be finished in the lathe and in (*b*) are shown the final dimensions obtained by grinding.

The first step in the finishing of the piston rod is to cut it off to about $\frac{1}{8}$ inch longer than the required length and then locate a center at each end. The centers are found by means of hermaphrodite calipers or a centering square and are marked with a center punch. Next the centers are drilled as shown in Fig. 14 by using a combination drilling tool or a drill and a 60° reamer. The rod is next mounted on its centers in the lathe and, as modern rods are 6 feet or more in length, a steady rest must be used at about its center. One end of the rod is then faced off; as the rod is only $\frac{1}{8}$ inch too long, not more than $\frac{1}{16}$ inch should be removed. Care should always be taken to remove as little as possible so that the center in the rod will not be cut out. The centers must never be cut out or damaged, because the rod is always mounted in them at the various shoppings. Once the centers are lost, new ones can not be located accurately enough to turn or grind the rod without wasting considerable time. If the centers are not found accurately, the rod will run eccentric when being reground, and, in truing it up, more metal will have to be ground off than necessary.

The tailstock end of the rod, which is assumed to be the piston end, is roughed out first to within about $\frac{1}{8}$ inch of its correct size and the collar is located $5\frac{3}{4}+3\frac{3}{8}=9\frac{1}{8}$ inches from the finished end. This dimension must be exact, because the piston and the crosshead are the proper distance, or 53 inches, apart when their faces are against these collars.

The end of the rod is roughed out parallel $3\frac{3}{8}$ inches and is threaded later for the nut. The taper is also roughed out to within $\frac{1}{8}$ inch of the dimensions shown and the body of the rod up to the steady rest is turned to a diameter of $4\frac{7}{8}$ inches.

29. After one-half of the rod has been partly finished, the rod is turned end for end and the other half is also roughed out to the dimensions shown on the print. The rod is now $\frac{1}{8}$ inch oversize and it is reduced to the proper diameter by grinding. If the grinder is not equipped with a tapering device, the tapered ends of the rod must be finished on a lathe to a taper of $\frac{3}{4}$ inch in 1 foot. The rod must be tried for fit before being turned down to the dimensions of the print, because no matter how carefully the taper is turned, it will seldom fit in the crosshead or piston with the accuracy required by a job of this nature. A good taper fit can only be obtained by trial and it is made by starting with an oversize rod at approximately the correct taper, and then trying the taper and correcting it until it corresponds to the taper of the crosshead or piston. Before the taper can be conveniently tested, the shank should be turned or ground until it enters about three-quarters way into the crosshead or the piston. The fit is tried by driving the rod in with a soft-faced hammer; points where the rod is bearing heavily will be shown by a slight marring of the finish. Some workmen coat the rod with chalk or red lead.

If the surface is found marred near the small end of the shank, the machine is reset and more material is removed from this end than from the other end on the next cut. If the marred surface is found to be near the face of the crosshead or piston, the machine is reset so that more is removed from the large end when making the next cut. The testing, resetting, and turning or grinding is continued in this way until the shank, when driven in, bears all around with the collar not closer than $\frac{1}{16}$ inch from the crosshead or piston.

30. If, on one of the trials, the rod is found to drive in exactly $\frac{1}{16}$ inch from the collar, no more should be turned off, because it is desired, in order to make a tight fit, to draw the rod this amount into the crosshead by the key. However, if the taper is found to be good and the collar is assumed to be $\frac{1}{2}$ inch from the crosshead, the taper is correct, but the shank is slightly oversize and must be reduced in diameter all over to permit it to go in another $\frac{7}{16}$ inch. The amount the diameter has to be reduced is found by calipering the large end of the bore in the piston or crosshead with inside calipers, then transferring the reading to outside calipers, and finally turning the shank down next to the collar until the feel of the calipers indicates that the size will be a little larger than necessary to make a metal-to-metal fit. The feed is then thrown in and the cut is continued over the rest of the shank. The workman, if experienced in handling calipers, can easily turn the shank so that it will drive in $\frac{1}{16}$ inch from the crosshead, thereby leaving this amount to be drawn in by the key.

As soon as both tapers are fitted, the crosshead is again driven on and the keyway is marked on the shank by using the slots in the crosshead as a guide.

The rod is driven out again, the marked keyway is shifted $\frac{3}{16}+\frac{1}{16}=\frac{1}{4}$ inch toward the collar to provide clearance for drawing the rod back tight against it. This clearance also takes care of the draw of the rod when it is reconditioned after being in service. The arrangement of the key and the slot in the rod and the crosshead for drawing the rod back tight will be evident from a study of Fig. 15.

31. Before milling the slot, a hole is first drilled for the cutter; the back of the slot is milled to a taper of $\frac{1}{2}$ inch in 12 inches. In the meantime the tapered key is forged and machined to the dimensions shown in Fig. 15. The correct taper is obtained by repeated trials in the crosshead with the piston rod in place. The chamfer at the ends *a* and *b* of the key prevents the ends from flattening out during application.

The piston is now applied permanently, care being taken that the wide wearing surface is as near the bottom as possible. The piston and the crosshead when drawn up tight against their collars will be the correct distance apart, or 53 inches.

Some roads prefer to leave $\frac{1}{16}$ inch or more between the face of the crosshead and the collar so as to make it unnecessary to correct looseness by removing the rod and turning off the collar slightly, as must be done when the crosshead is fitted against it. In this event, the shank is fitted until it drives in $\frac{1}{8}$ inch from the collar, thereby allowing $\frac{1}{16}$ inch for draw.

Sometimes a collar is not used on the crosshead end of the rod; the drawing then shows how far the crosshead is to go on.

If it should happen that the rod is not tried for fit before being turned down to the dimensions shown on the print, it will be generally found that the tapers do not correspond, as shown exaggerated in Fig. 16. A correction cannot usually be made, because so much would probably have to be turned off the collar that the crosshead would be brought too close to the piston. A slight variation from the standard dimension, or 53 inches, would not matter, as the correction could be made in the main rod. All that can be done if the fit is poor, is to have another crosshead and piston, if available, turned up to a slightly smaller diameter, and the rod again finished to suit. If this cannot be done the rod will have to be discarded.

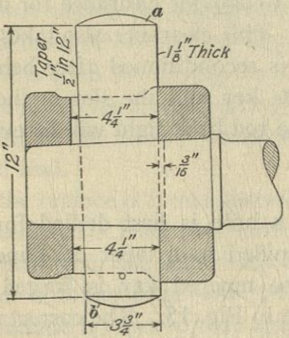


FIG. 15

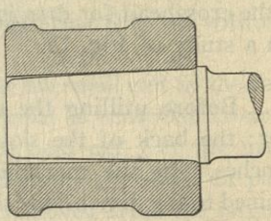


FIG. 16

It must be remembered that with the tapers correct, a very slight amount turned off the collar will correct a loose fit. It is only when the tapers do not correspond that the amount to be turned off becomes so much as to shorten the rod.

32. Reason for Tapered Fit.—The piston rod has a tapered fit because it is possible to maintain such a fit tight without affecting appreciably the length of the rod.

With a parallel fit, the rod when first applied would be held tight in the crosshead between the key and the collar, also the parallel surface of the rod would make a tight fit in the crosshead. The pulls and thrusts on the rod would finally bring the collar into more intimate contact with the crosshead, the result being a slight movement that will cause wear on the straight surface. Also the rod, each time it is disconnected from the cross-head, will go back in slightly looser than before. Such wear on the straight surface could not be taken up.

With a taper fit, Fig. 15, the rod is held tight by pulling the entire bearing surface up against the cross-head fit with the key. Any looseness can then be taken up by turning a small amount off the collar and then drawing the rod back into the crosshead by driving down the key. With no collar it will only be necessary to drive down the key to correct the looseness.

33. Repairing Old Rods.—Piston rods will gradually become worn out of round because of the friction of the packing. Although it is supposed to do so, the packing does not always press evenly against the rod, and some parts of it will then wear faster. The packing will also cause a shoulder to form on the rod at the end of each stroke. The rod, if not worn to the condemning limit, is trued up by turning or grinding.

Old piston rods should be examined for evidence of the shank working in the crosshead, and the rod should be carefully inspected for cracks, especially around the keyway. The indication of a rod working is an absence of tool marks at certain points; if the rod has been ground it will be noted where the finish is disturbed.

Cracks are detected by thoroughly cleaning off all oil that may have accumulated on the rod during service, and then coating it with whitewash. When the rods become dry, the cracks will be disclosed, as the oil that has remained in them after the rod was cleaned, seeps out and discolors the whitewash. Any flawed or cracked rods are discarded.

A shank that has been found working is tightened by removing as little metal as possible when cleaning up the shank and then turning the required amount off the collar to tighten the rod. Some roads permit as much as $\frac{3}{16}$ inch to be turned off the collar in such cases, and, as this shortens the piston rod by the same amount, the required cylinder clearance is obtained by lengthening the main rod.

CROSSHEAD WORK

34. General Description.—The purpose of the crosshead, which is made of cast steel, is to connect the piston rod to the main rod and to relieve the piston rod of any sidewise stress, which is liable to bend it.

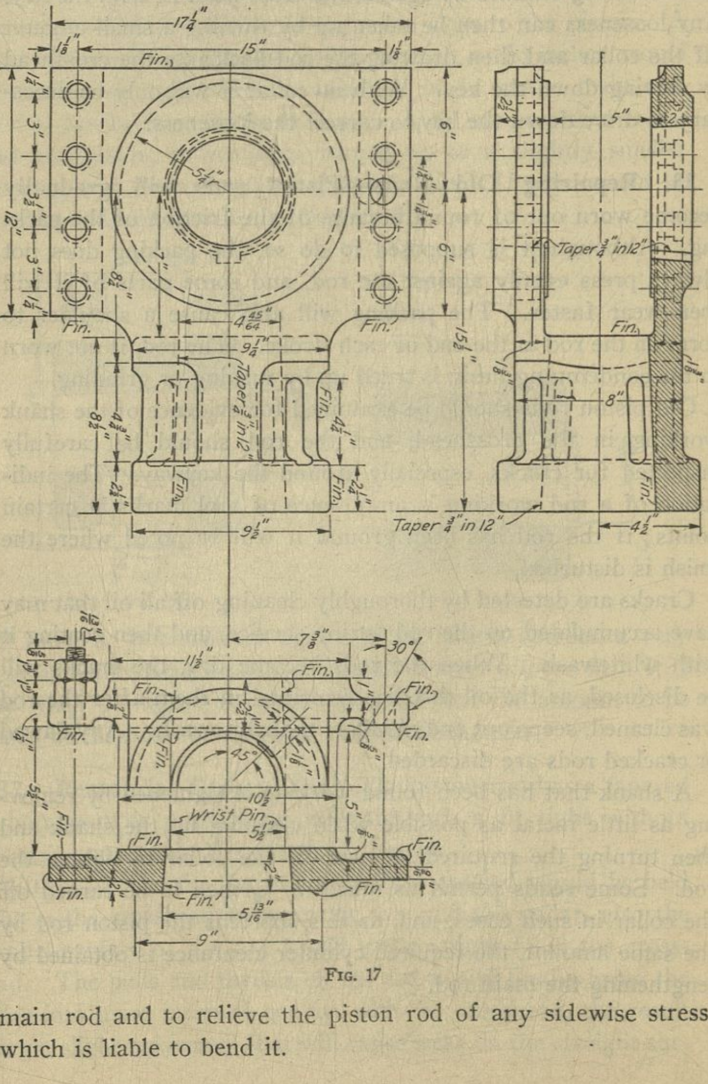


FIG. 17

The types of crossheads in most general use are the alligator type, Fig. 17, the Laird type, Fig. 18, and the Dean type, Fig. 11, used with the center cylinder of three-cylinder locomotives. With the alligator type, the crosshead is located between an upper and a lower guide, and is guided laterally by shoes with flanges that project over the sides of the guides. With the Laird type, a block in the top of the crosshead slides between two guides, the lower one of which passes through the crosshead. The lateral movement is prevented by the surfaces of the crosshead bearing against the sides of the bottom guide. The Laird type of crosshead is lighter than the alligator type, and hence makes possible a reduction in the weight of the counterbalances on the driving wheels.

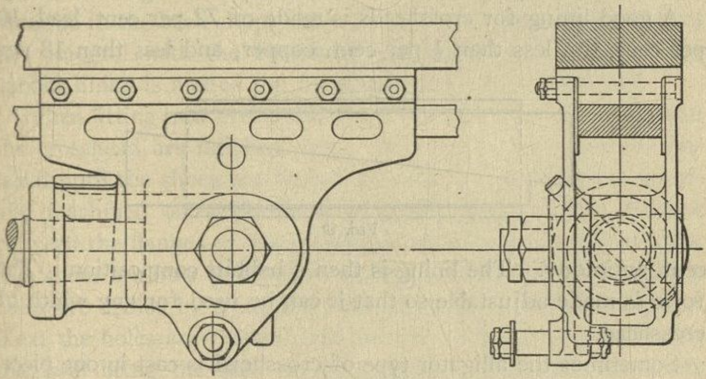


FIG. 18

The type of alligator crosshead shown is made in three parts, the crosshead proper, and two shoes, which in this case are of brass. However, the shoes may be of cast steel with dovetailed slots to retain a lining of suitable wearing material, which is poured in. In addition to having the slots, the shoes must also be tinned to insure that the lining is held in; also, a ridge is generally brazed on each end to prevent the lining from crumbling at these points.

Although the term tinning is used, the mixture is really half tin and half lead. To tin a surface it is scraped, cleaned, and heated by immersing it in the molten lining metal, then the sal-ammoniac and the tinning mixture, which comes in sticks, are run on together. The tinning mixture is spread and rubbed in with a stone. Unless first tinned, the lining material would not adhere to the steel.

A form, a top view of which is shown in Fig. 19, adjustable as to width, is used when pouring the lining to prevent the shoe from filling up level. This form is laid on the brazed ridges, then adjusted central between the flanges, and made narrow enough to allow for excess material when finishing. The ends of the shoe are next stopped up with fireclay to prevent the metal from running out. The cavity on each side and under the form is then completely filled with the molten metal.

A good lining for crossheads is made of 72 per cent. lead, 10 per cent. tin, less than ½ per cent. copper, and less than 18 per cent. antimony. The lining is then a babbitt composition. The form is made adjustable so that it can be used for any width of crosshead.

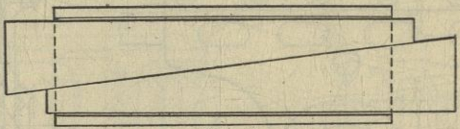


FIG. 19

Sometimes the alligator type of crosshead is cast in one piece, in which event a brass or babbitt lining, held in place by slots and tinning, is also applied.

The block of the Laird crosshead is tinned and is then lined on the top and bottom surfaces with the bearing material. The lateral bearing surfaces on the sides of the crosshead are also tinned and lined.

35. Repairing Old Crossheads.—Old crossheads are thoroughly cleaned and are then examined carefully for cracks, which are most liable to be found on the wristpin bosses and piston-rod socket. Cracks can be located by whitewashing the crosshead after it has been cleaned; when dry, the cracks will be indicated by the oil in them seeping out and discoloring the whitewash. Some roads prohibit the welding of cracked crossheads; others permit this practice.

The work on the body of the crosshead is limited to cleaning up the hole for the wristpin. This hole will almost always be found worn out of round, and if not already too large it is trued up on the boring mill in much the same manner as when a new crosshead is machined. The bosses around the wristpin hole serve to strengthen the crosshead at this point and they should be trued up if found marred. The clearance between the bosses on the inside must be calipered and compared with the width of the front end of the main rod so as to detect excessive lateral movement.

36. Fitting the Shoes.—Shoes that are all brass are renewed in the back shop, but with cast-steel shoes or with shoes cast integral with the crosshead, the lining is renewed. The babbitt lining is melted out by dipping in a hot babbitt bath.

When fitting new crosshead shoes, the surfaces that fit against the crosshead are finished first; the other surfaces are not finished until the shoes are bolted in place. The shoes are generally machined on a planer to a width equal to the distance between the flanges of the crosshead, and the fit should be tight. The shoes are now clamped in position on the crosshead and the holes are drilled by using the holes in the crosshead for a guide. Next the holes are reamed and the bolts fitted from a direction that will bring the nuts on the outside. After the shoes are fitted, the bearing surfaces are finished by planing or milling.

37. Machining Bearing Surfaces.—The guides were hung in relation to the cylinder axis, that is, as shown in Fig. 1, they were lined up parallel to the cylinder axis, and also with their vertical centers in line with this axis. Therefore, in order that the crosshead may work in the guides without binding, its bearing surfaces must also bear the same relation to the cylinder axis as the guides. The center line of the piston-rod socket in the crosshead may be considered as a continuation of the cylinder axis, hence the bearing surfaces of the crosshead will be finished properly when machined with respect to this center line.

The main bearing surfaces as shown in Fig. 1 must therefore be machined parallel to the center line of the piston-rod socket, also the lateral bearing surfaces must be machined so that a point midway between them at the top and bottom will be in line vertically with the center line of this socket.

38. Locating Flange Centers Midway of Piston-Rod Socket. When beginning the work of locating the flanges of the new shoes midway of the center of the piston-rod socket of the old crosshead, a rod resembling a piston rod is first set up in V blocks on the planer table and is clamped exactly level by testing with the surface gauge. Next, the crosshead is mounted on parallels and, after being driven on the piston rod, is tested with a square and is made exactly vertical. The slides shown on the square, Fig. 20, are contact points that prevent any burrs on the face of the bosses from giving a false reading. With new work the slides are not necessary. The weight of the crosshead tends to spring the rod slightly; therefore, after the crosshead has been packed up, additional packing of from $\frac{1}{32}$ inch to $\frac{1}{16}$ inch, depending on the weight of the crosshead, is applied to take out the sag in the rod before it is clamped down.

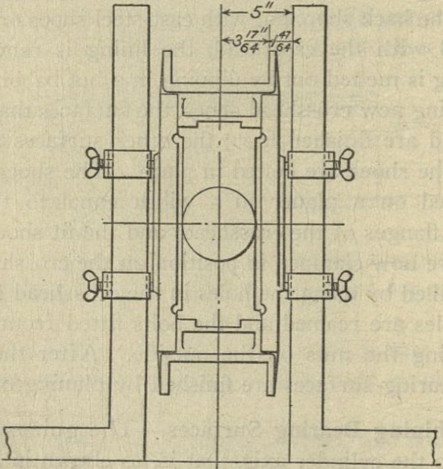


Fig. 20

When planing new crosshead shoes, a point midway of the flanges must come directly above the center line of the socket. To obtain this point, the distance is measured from the center of the socket to the finished face of either boss, preferably the one in the best condition, and to this is added an amount equal to the contact points of the square, Fig. 20. For example, if the distance between the center of the socket and the boss is $4\frac{1}{2}$ inches and the contact points measure $\frac{1}{2}$ inch, the face of the square then comes 5 inches from the center of the socket. Then one-half of the width of the guide, or $3\frac{1}{4}$ plus $\frac{1}{64}$ for clearance, or $3\frac{17}{64}$, is subtracted from 5 inches, thereby obtaining $1\frac{47}{64}$ inches. A point is now located on the flange this amount from the square, and the flange is machined up to it. Another point is made on the opposite flange by means of the dividers set to the width of the guide plus the total clearance, or $\frac{1}{32}$ inch.

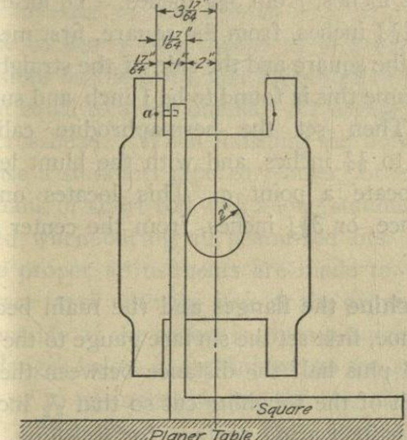


FIG. 21

The distance between the boss and the center of the socket is obtained by holding a straightedge against the boss in a horizontal position and level with the piston rod. Then the distance is measured from the straightedge to the rod and one-half the diameter of the rod is added. This distance is generally standard for the same class of engine.

The bottom flanges are marked off and machined in the same way after the crosshead is inverted.

39. If it is desired to lay off and machine the flanges from the piston rod or its socket, the following method can be used:

First clean up the flange of one shoe, then apply a square against the piston rod or its boss, and place a straightedge, Fig. 21, against the surface just cleaned up. The width of the crosshead is here shown exaggerated so as to make the dimensions clearer.

If the width of the guide is to be $6\frac{1}{2}$ inches and the clearance is to be $\frac{1}{32}$ inch, then the distance between the flanges is to be $6\frac{17}{32}$ inches and one-half the distance is to be $3\frac{17}{64}$ inches. To lay off one flange this distance from the center of the piston rod, subtract one-half the diameter of the rod where the square touches it, or 2 inches, from $3\frac{17}{64}$ inches. To locate a point this difference, or $1\frac{17}{64}$ inches, from the square, first measure the distance between the square and the side of the straightedge against the flange; assume this is found to be 1 inch, and subtract it from $1\frac{17}{64}$ inches. Then set the hermaphrodite calipers to the remainder, or to $\frac{17}{64}$ inches, and with the blunt leg against the straightedge locate a point *a*. This locates one flange the required distance, or $3\frac{17}{64}$ inches, from the center of the piston rod.

40. To machine the flanges and the main bearing surface of the upper shoe, first set the surface gauge to the center on the end of the rod plus half the distance between the guides, then gauge the depth of the roughing cut so that $\frac{1}{32}$ inch will be left on the upper main bearing surface for finishing. Then finish one flange to the mark *a*, Fig. 21, already made and the other one the specified distance from it. The main bearing surface is next finished. Next, mark off and finish the other shoe in the same manner after the crosshead is inverted.

The utmost care may be taken in lining up the guides, but this is of little use unless the crosshead shoes are machined properly.

41. Machining New Crossheads.—A copy of a blueprint of a crosshead is shown in Fig. 17. The top and bottom of the flanges are machined on the planer and the surfaces between the jaws that determine the lateral play of the front end of the main rod are machined on the slotter when the work cannot be done on the boring mill. The piston-rod socket is bored out and the outside of the boss is finished on the boring mill.

The piston-rod socket is bored out first because the flanges and the bosses of the crosshead have to be machined with respect to the center of this socket. This work is done by first setting the casting up as nearly vertical as possible on the boring mill table. The best plan, when setting up the casting for this work, is to bolt or clamp it to a right-angle bracket on the boring mill table. Next, with a pointer in the tool holder, the casting is revolved and shifted until the pointer indicates that the piston-rod socket is concentric with the table, then the right-angle bracket is permanently tightened. The socket is roughed out after the boring bar has been adjusted to bore a taper of ¾ inch per foot. The outside of the socket is then turned to within a small amount of the dimensions on the print, and the top of the socket is faced off an amount equal to about one-half the excess material on the ends of the crosshead. When finishing the bore of the socket, some shops use a standard tapered reamer; others make the fit by trying a shank or short rod with a long standard taper so that it can be used when boring all piston-rod fits. This shank is tried and the proper adjustments are made to the machine to obtain the exact taper with the bore at the proper size.

Next the outside of the socket is given a finishing cut and the ends of the flanges below it are finished to the radii shown to a point 15½—6 or to 9½ inches, below the top of the socket.

42. The crosshead is now sent to the planer, where it is mounted on the rod and packed in place as explained under planing the shoes. The top and the bottom of the flanges are planed until, as shown by the surface gauge, they come 8¾ inches from the piston-rod center, which was marked on the end of the rod when the shank was made.

The surfaces between the flanges against which the shoes are fitted are now planed 5½ inches apart, or 2¾ inches on each side of a center line, which can be found by the method explained in Art. 39. The first method, Art. 38, cannot be used because the bosses on the side of the crosshead are not yet machined. The flanges on the bottom are planed in the same manner. Another good method of planing these surfaces is to mount the crosshead on its side, and check the work with a surface gauge.

Next, the wristpin hole is bored out on the boring mill. Before centering the casting on the table, a wooden bridge is inserted in the cored hole and the wristpin center is properly located on it, or at a point 15½ inches from the face of the boss and midway of the flanges. Then with this point as a center, a circle is scribed with a radius slightly larger than that of the wristpin. The circle is prick-punched at the quarters and eighths and is to be used when centering the casting on the table. The wooden bridge is then removed and the casting is adjusted so that the circle runs concentric with the pointer and is leveled crosswise by applying a surface gauge on the inside of the flanges, which have already been finished. If already made, the wristpin is used as a gauge when boring the hole; if it is not made, a standard tapered shank is employed. The correct taper, or ¾ inch to the foot, can be most easily obtained by using a reamer of this taper to finish the hole after it has been roughed out.

The sides of the crosshead are now faced off and the dimensions shown in the print are obtained between them and the surfaces already machined. It will be noted that the wristpin boss on the inside is 2 inches thick and on the outside 2½ inches thick; the lesser thickness on the inside is to provide for clearance between the crosshead and the side rod.

To face off the bosses between the flanges on the boring mill to within ¼ inch of the finished flanges requires a special spot-facing tool. If such a tool is not obtainable, this work has to be done on the slotter.

Finally, the crosshead is properly set down on the slotter and the ends of the flanges are finished to within 6 inches of the center of the wristpin hole.

PISTON-RING WORK

43. Description.—The piston rings are designed to prevent any leakage of steam past the piston. They are either of the snap-ring type or the built-up type, and are made from a good quality of cast iron or gun iron. This material is used because it machines easily and it wears to conform to the bore of the cylinder.

The general practice is to use snap or one-piece rings but they have the disadvantage of not pressing evenly against the cylinder all the way around, especially if the cylinder is large. Also, such rings have a tendency to lose their spring, owing to the high temperature of the steam and to the fact that they are always under compression. The built-up types of rings do not have these disadvantages.

The Dunbar piston rings, Fig. 22 (*a*), are of the built-up type, and consist of two rings, each divided up into eight segments. A segment of one ring is riveted to a segment of another ring after first being matched as shown in Fig. 22 (*b*). This riveting together of two segments serves to break the joints between all the other segments when they are applied loose. As the segments have no tendency to expand like a snap ring, a steel spring has to be used to hold the segments out against the cylinder.

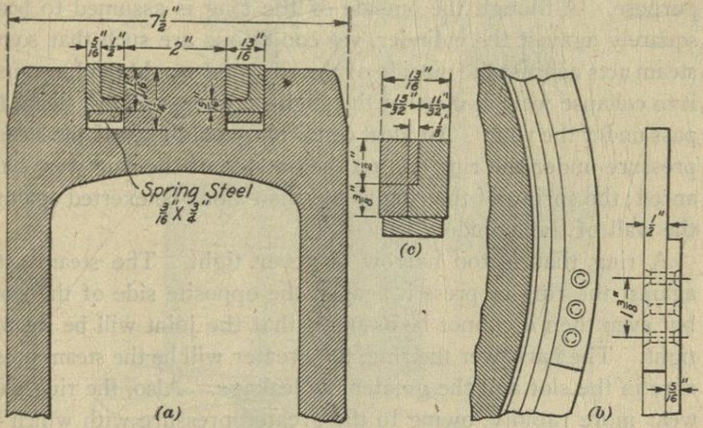


FIG. 22

Dunbar rings, because of being made in short sections, fit the bore more accurately than a snap ring, they are less liable to break, and, unless broken at the end of another segment, they will not leak; whereas one break renders a snap ring useless. However, the Dunbar rings are more expensive to apply, but they will generally last from shopping to shopping.

The Dunbar rings as well as the Duplex rings, Fig. 22 (*c*), are locked together as shown, to prevent expansion into the counterbore in the event of overtravel unless the entire ring moves beyond the counterbore.

44. Action of Steam on Rings.—The width of snap rings should be as close to the width of the grooves as will permit them to be applied easily and also allow them to expand freely in the groove out against the wall of the cylinder. These conditions will be met if the rings are made $\frac{1}{64}$ inch narrower than the grooves. The slight looseness in the groove also serves another purpose. Although the outside of the ring is assumed to bear squarely against the cylinder, yet conditions are such that some steam acts against the outside of the ring and would tend to cause it to collapse were it not that the slight looseness allows steam to pass under the ring. An ideal condition would exist if the steam pressure under the ring and on the outside of the ring were balanced; the spring of the ring would then alone be exerted against the wall of the cylinder.

A ring that is too narrow is never tight. The steam acts against the ring to press it against the opposite side of the slot, but even then it cannot be assumed that the joint will be steam-tight. The narrower the ring, the greater will be the steam pressure in the slot and the greater the leakage. Also, the ring will wear more rapidly, owing to the greater pressure with which it is forced out against the cylinder. Narrow rings will also slap in the grooves when the piston reverses, and will widen the grooves so much that a special ring will have to be made or the bull ring renewed. For a ring to be steam-tight requires that as much of the slot as possible is filled by the ring.

With the Dunbar rings, the segments are short, and they can be made to fit the slot more closely than a snap ring. As a result, steam cannot find its way to the bottom of the slots, and act to prevent the segments from collapsing; holes have then to be drilled for this purpose. When the segments are made narrower, the holes do not have to be used.

45. Manufacture.—The piston rings are machined from cylindrical castings with lugs cast on their bases to permit them to be secured to the boring-mill table. To give the rings the required spring when applied, the casting is turned to a larger diameter than the cylinder, the amount depending on the railroad company's standard. The diameter to which the casting is bored depends on the depth of the ring. If the ring is to be $\frac{7}{8}$ inch, the casting will be bored $1\frac{3}{4}$ inches less than its outside diameter.

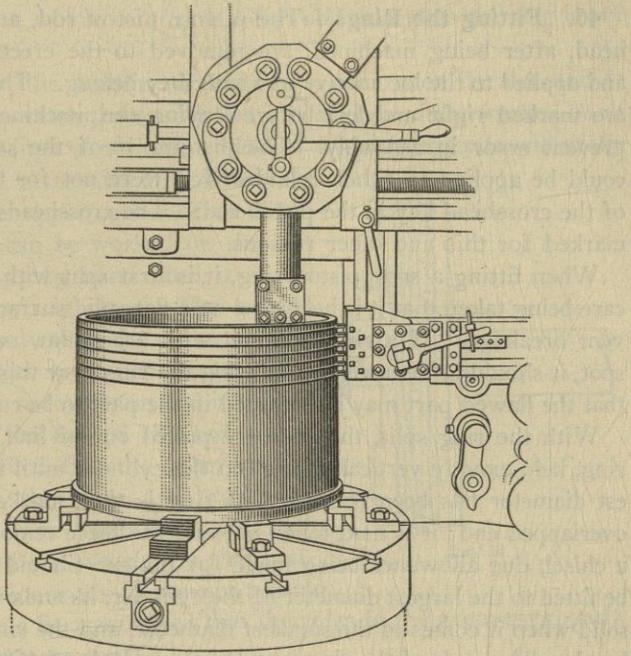


FIG. 23

After the casting has been turned and bored and the top faced off smooth, it is separated into rings by means of a series of parting tools held in one holder, Fig. 23. The holder is so arranged that the top tool will start cutting first and the bottom one last. Also, the tools are arranged to cut the rings slightly thicker than required to permit the sides to be faced smooth.

The upper ring, when cut through, is removed to avoid being damaged and, before the second ring is severed, its upper surface should be faced off quickly. All of the rings are cut and faced in this manner and when the last one is severed the holder is again reset to take off another series.

All the rings are then sent to a lathe or to an improved piston-ring facer, where the unfaced sides of the rings are brought down to the required thickness, or about $\frac{1}{64}$ inch narrower than its groove.

46. Fitting the Rings.—The piston, piston rod, and crosshead, after being machined, are removed to the erecting floor and applied to the locomotive to which they belong. These parts are marked right and left before leaving the machine shop to prevent error in assembly. The pistons, if of the same size, could be applied to either cylinder if it were not for the angle of the crosshead key in the piston rod. The crossheads are also marked for this and other reasons.

When fitting a snap piston ring, it is first split with a chisel, care being taken that it is held level on a flat solid surface to prevent breakage. If a ring is found with a bad flaw or a weak spot, it should be removed by splitting the ring near this point so that the flawed part may be included in the part to be cut out.

With the ring split, the ends are pulled out of line, and the ring, held exactly vertical, is tried in the cylinder until its smallest diameter has been found. The ring is then marked at the overlapped end; it is next taken out and the piece removed with a chisel, due allowance being made for filing. Should the ring be fitted to the largest diameter of the cylinder, its ends would go solid when it comes to the smallest diameter, and the ring would break. The ends of the ring are filed at an angle of 45°, and the ring is again tried in the smallest diameter of the cylinder. If the ends overlap or if there is not the required gap between them, the filing is continued until there is a clearance of $\frac{1}{16}$ inch to $\frac{3}{16}$ inch between the ends. This is to allow for the expansion of the ring.

Sometimes the ends of the rings are finished straight across. The advantage of a diagonal cut is that the ring cannot leave a ridge in the cylinder along the line of joint travel. However, ridges will rarely appear, if the cuts when straight are kept near the bottom of the cylinder with no two on the same line.

47. Application of Rings.—Piston rings are very easily broken if not applied in the proper manner. The ring for the middle groove is put on first so that it will not have to be applied over the other rings. To apply the ring, the piston is lifted clear of the floor, the ring joint is placed down nearest to the floor, and the ring is tilted at an angle to the head as shown in Fig. 24. It is then rapped lightly with the end of the hammer handle at the point *a*, which, of course, keeps shifting up as the ring is put on farther.

Finally, the bottom of the ring comes over its slot and is allowed to catch there. The ring is next carefully worked on at the top a little at a time; a blow of any consequence will easily break it. After the top of the ring passes the upper corner of the head, the ring can be worked on the rest of the way by hand until it finally drops down in place. The outside ring is put on in the same manner but it goes on much easier. The ring next to the piston rod is slipped on over the end of the rod and is then applied like the others. The joints in the rings are broken by turning them until they are 180° apart, and are doweled in this position by some roads to prevent turning.

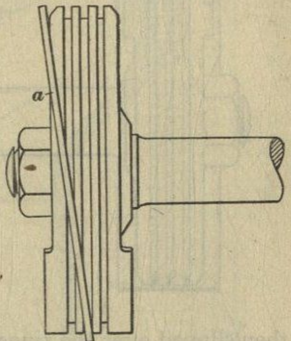


Fig. 24

It should be ascertained that the rings fit the grooves properly before they are applied.

Owing to its weight, the portion of the ring in the bottom of the cylinder wears more rapidly than any other portion. With the heavier portion of the ring at the top, the ring is unbalanced and the result is a gradual movement around the piston as the wear progresses.

Some workmen prefer to apply the rings in another manner. The ring is placed flat against the piston, then one end is entered into the groove by springing this end away from the other end; the remainder of the ring is then gradually worked into place a little at a time. Either method of application imposes a severe strain on the ring; this is rather an advantage because a ring with a hidden defect will generally break during application.

48. Application of Dunbar Packing.—The spring of the Dunbar and the Duplex packing is applied first in the same manner as the ordinary snap ring. The piston is then mounted on the floor or bench with the rod upwards, and the riveted segment is applied first; next one groove is filled with the segments that rest on the spring, and the other segments are applied last. A sheet-metal band or clamp, Fig. 25, with a tightening screw is then slipped over the rings to hold them in place. The segments are next applied to the other groove and the band is lowered to hold them in place. Finally, the band is tightened up with the wing nut.

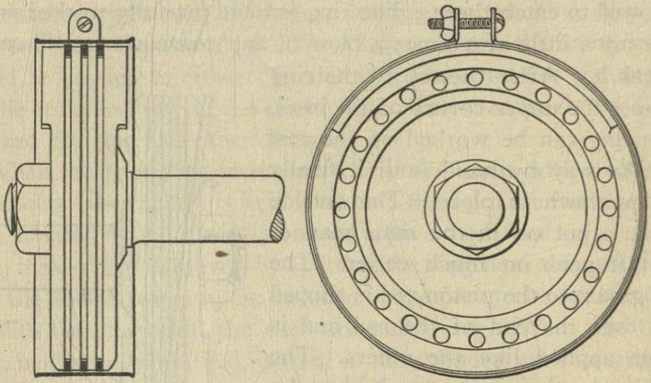


FIG. 25

49. Application of Piston.—Before the piston is applied, the channels, ports, and exhaust passages are blown out with compressed air, and temporary covers are applied at all the openings through which cuttings or nuts might fall. The bore of the cylinder is then coated with lubricating oil because some time might elapse before the oil would reach the cylinders from the lubricator. Next, the piston and rod are picked up by the crane by hooking a sling around the rod next to the head, and the crosshead end of the rod is inserted through the stuffingbox hole in the back cylinder head. A block is then placed directly

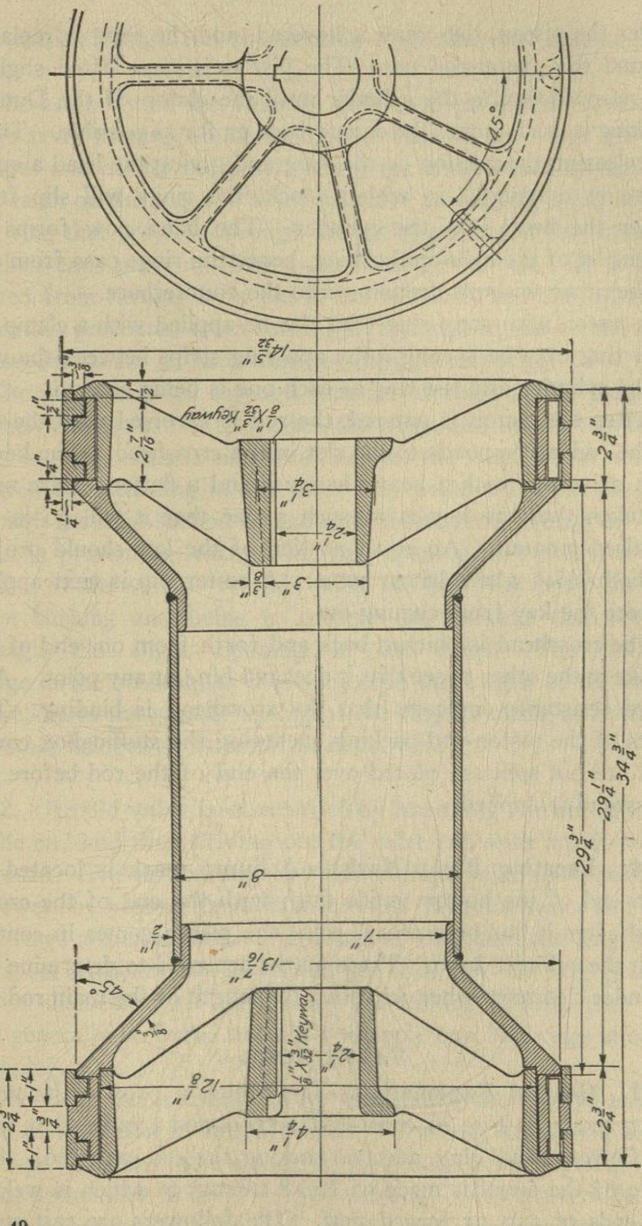

45°
14 5/32"
3/8"
1/2"
1/2"
2 7/16"
1/4"
1/4"
1/8" X 3/32" Keyway
3 1/4"
2 1/4"
3/8"
3"
2 3/4"
29 3/4"
29 1/4"
34 3/4"
8"
7"
1/2"
13 7/16"
45°
3/8
1/8" X 3/32" Keyway
2 1/4"
12 1/8"
4 1/4"
1"
3/4"
1"
2 3/4"
2 3/4"

Fig. 26

under the piston, the crane is lowered, and the sling is replaced around the piston-rod nut. The piston is next lifted slightly and is pushed into the cylinder until the clamp, if the Dunbar packing is used, enters the counterbore as far as possible. Then, by releasing the tension on the sling and giving the head a quick shove or driving it in with a block, the rings will slip from under the band into the cylinder. The band now forms an extension of the cylinder bushing, hence the rings pass from one to the other without dropping into the counterbore.

A piston with snap rings can also be applied with a clamp, or each ring may be sprung in by applying strips between the wall of the cylinder and the ring as each one is being entered.

After the piston is entered, the rod is revolved until the slot in the rod corresponds to the slot in the crosshead. The key is then driven in with a heavy hammer and a flatter. Care must be taken that the key is of such a size that it will go in the required amount. An equal portion of the key should project on both sides when driven home. A cotter pin is next applied to keep the key from coming out.

The crosshead is pinched back and forth from one end of the stroke to the other to see that it does not bind at any point. Any extra resistance indicates that the crosshead is binding. The parts of the piston-rod packing, including the stuffingbox cover, that are not split are placed over the end of the rod before the crosshead is applied.

50. Locating Bump Marks.—A bump mark is located on each end of the bottom guide flush with the end of the crosshead after it has been moved until the piston comes in contact with the cylinder head. These marks are used to determine the cylinder clearance when adjusting the length of the main rod.

VALVE WORK

51. General Explanation.—The valve, a copy of its print being shown in Fig. 26, consists of a spool and a valve stem, with a follower, a bull ring, and two packing rings at each end. The body of the spool is made of No. 8 tubing, to which is welded the ends of cast or forged steel. The followers are cast steel, and the bull rings and the packing rings are cast iron or gun iron.

The assembly of the valve is such as to prevent the packing rings from turning and bringing the ends of the rings off the bridges and across the ports, where the ends would spring out and catch on the edges. With the valve assembled, a pin in the bull ring that projects through the packing rings at the junction of their ends prevents them from turning, the bull ring is prevented from turning by a pin in the follower, and the follower in turn is prevented from turning by a dowel in the valve stem. These details are all shown on the copy of the print.

The pin is inserted through each set of rings at the junction of their ends so as not to weaken the rings, and this brings their ends in line. This is not desirable, yet the rings could not be secured from turning in any other way without the pin passing through the solid section of one ring, thereby weakening it. To assist in preventing leakage, the ring openings are placed at the bottom of the valve. At this point the bull ring bears on the valve bushing and helps to prevent any leakage that occurs through the slight opening in the rings. The bottom bridge in the bushing, as it is subject to the weight of the valve as well as to the greater spring of the ring, is made wider than the other bridges so as better to resist wear.

52. An old valve is dismantled by removing the nut or nuts at the end and then driving out the valve rod with a soft-faced hammer. The carbon may be burned off the valve spool and the followers by heating them in a furnace. The followers and the bull rings are examined for cracks and wear, and the length of the spool is also measured and marked on it. A bull ring $\frac{3}{32}$ inch less in diameter than the bore of the bushing is discarded. It will generally be found necessary to apply new bull rings at each shopping.

The valve rod is examined for cracks, and the tapered end is tried in its socket in the crosshead. If cracks are found or if the taper is found to be a poor fit, the rod must be renewed, if it is not permissible to build it up by welding. New valve rods are roughed out on a lathe and are finished by grinding. Old valve rods that are found serviceable, are ground true on the grinding machine, care being taken that the diameter is not reduced below the size desired. A good smooth finish is essential to prevent the packing from being unduly worn by the movement of the rod.

53. Making Up Valve to Suit Port Spacing.—The length of the valve spool depends on the port spacing and this is seldom identical on two engines of the same type. If the valve bushings are not to be renewed, they will usually be found slightly farther apart than when originally applied. If new bushings are applied, the spacing is also liable to vary slightly from standard. Therefore, the valve spool is seldom made to the length shown on the print, but is made to suit the port spacing. Otherwise, the proper steam lap will not be obtained.

The length of the valve spool depends on the port spacing, the steam lap, and the depth of the recess in a steam ring, and is equal to the port spacing less twice the steam lap plus the depth of the recess in a steam ring. For example, assume the port spacing is found to be 31¾ inches and the print shows the steam lap to be 1¼ inches and the recess in the steam ring to be ¼ inch; then the length of the spool will be equal to 31¾ minus 2½ plus ½, or to 29¾ inches.

With the valve spool the correct length for the port spacing, it only remains to machine the bull rings and the followers to the dimensions shown on the print to obtain the required specifications on the exhaust edges of the valve.

A new valve rod is made up entirely from the print, an old one is cleaned up, but the length is left unchanged. As already stated, an error in setting the back bushing will require a change in the length of the valve rod, but this change is never made until setting the valves. The valve rod could be corrected for a misplaced back bushing when assembling the valve, but it will generally be found that further changes in the length of the rod will have to be made later when setting the valves; hence all corrections are made at that time. As already explained, this involves either turning some off the collar or applying a washer next to the collar.

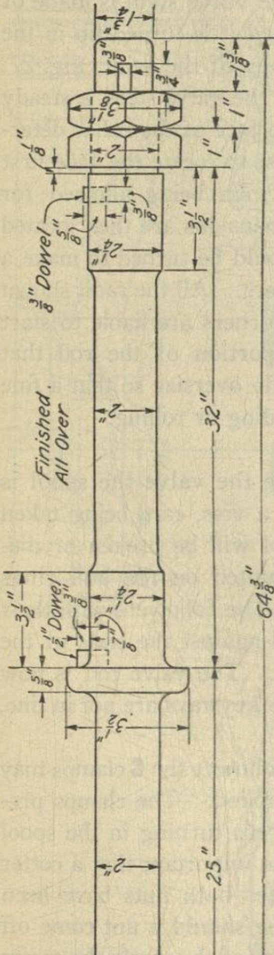


FIG. 27

54. Fitting Valve Rings.—The valve packing rings are turned from hollow cylindrical castings of cast iron or gun iron. More work is involved in turning valve rings than piston rings, because the former must be recessed separately. The outside of the cylindrical casting, or tub, as it is commonly called, is turned larger than the bore of the steam chest by the amount specified by the standards of the railroad. After being turned off, the rings are cut square across, the ends are then pulled out of line, and the rings are applied in a sleeve slightly larger than the bore of the steam chest. Enough is then cut out of the rings so that, with the ends filed properly, the rings will fit in the sleeve with the ends $\frac{1}{32}$ inch apart. All of the rings are next placed together in the sleeve between two steel plates mounted on a heavy mandrel. The rings are then removed from the sleeve, the plates preventing them from expanding; the mandrel is mounted between lathe centers, and the outsides of the rings are turned to the diameter of the steam-chest bushings. The plates are next loosened and the rings are ready to be applied. Before being applied, they are tried in the steam chest and filed to fit if necessary.

55. Machining of Valve Stem.—The valve stem is made of forged steel and after being center-drilled it is turned up in the lathe to the dimensions shown on the copy of the print, Fig. 27. Owing to the length and slenderness of the valve stem, a steady rest must be used when turning it. The face of the collar determines the length of the rod and it is best to locate the face first $29\frac{1}{16}$ inches from the shank end, $\frac{1}{16}$ inch being allowed for cleaning up this end. All the other dimensions are then located from this face. The follower seats should be turned to make a good sliding fit in the bore of the followers. All the radii shown are to be machined on the rod; sharp corners are liable to start cracks and should be avoided. The portion of the rod that works through the packing is left a trifle oversize so that a fine polish or finish can be obtained by grinding or rolling.

56. Valve Assembly.—To assemble the valve the spool is first placed in a horizontal position in a vise, care being taken not to tighten it too much or the spool will be broken or distorted. The valve rings are then mounted on the bull rings and each one is placed on its follower. The followers with their keyways on the bottom are now placed against the ends of the spool where they are held by **C** clamps. The valve rod is now passed through the follower and, if their keyways are not in line, one follower is rotated until they are.

With the valve-rod collar against the follower the **C** clamps may be tightened and the valve-stem nuts applied. The clamps prevent the valve stem and the follower from turning in the spool during the application of the nuts. It is important that a cotter pin is inserted in the rod and split after both nuts have been applied. Serious damage would be done should a nut come off and get into a port. To check the accuracy of the work, the gauge is set to the distance between the steam edges of the ports, less the amount of two steam laps; the gauge should then fit snugly between the two steam rings. The distance between the edges of the steam and the exhaust rings is checked by a steel scale; this distance should be $2\frac{3}{4}$ inches.

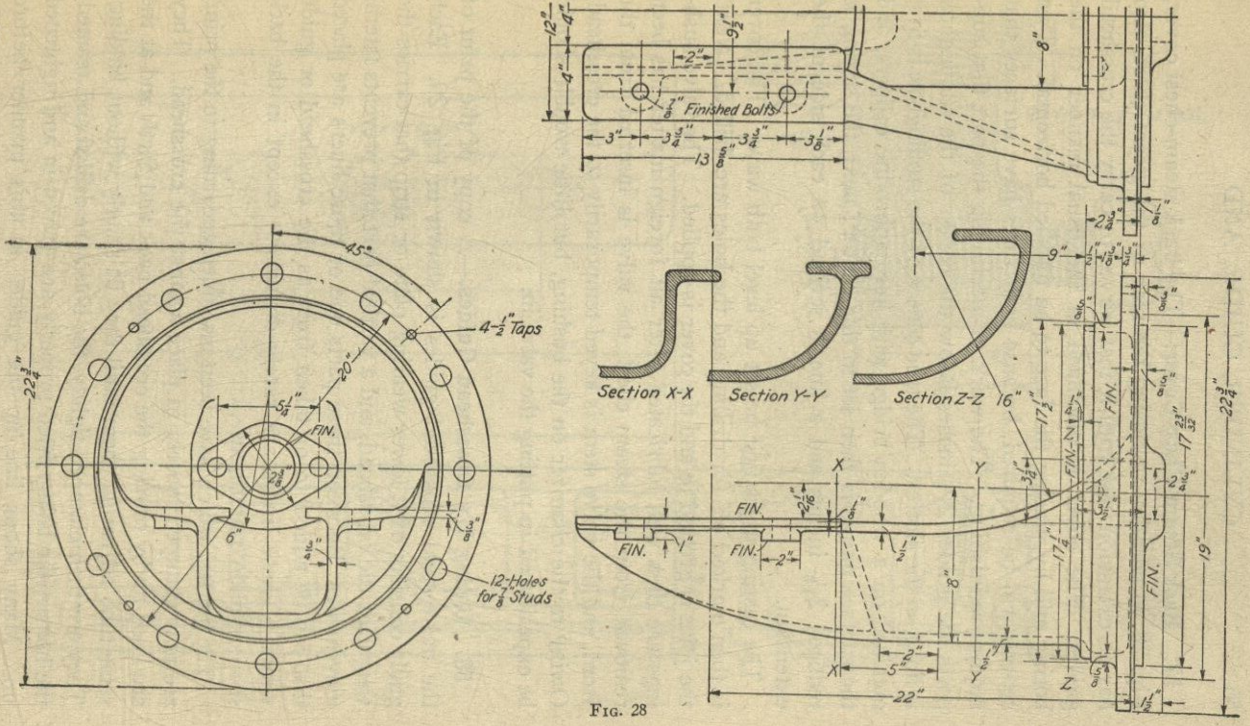

4-½" Taps
12-Holes for ⅞" Studs
45°
20"
5¼"
FIN.
2⅜"
6"
¾"
⅜"
22¾"
12"
4"
4"
9½"
2"
⅞" Finished Bolts
3"
3¾"
3¾"
3⅛"
13⅝"
8"
⅛"
2¾"
9"
½"
1⅜"
¾"
Section X-X
Section Y-Y
Section Z-Z
16"
X
Y
Z
FIN.
FIN.-N
2 1/16"
⅛"
1"
2"
½"
3¼"
3½"
17½"
17¼"
17 23/32"
2¾"
19"
22¾"
⅝"
⅜"
⅝"
1½"
1½"
8"
5"
22"
FIN.

FIG. 28

57. Back Steam-Chest Cover.—The back steam-chest cover, Fig. 28, in addition to closing the rear of the steam chest, also has an extension cast with it that serves to carry the crosshead guides. The cover is machined in the usual manner on the boring mill by placing the face to be finished horizontal. Two set-ups will be required, because both sides have surfaces that require refinishing. The work of machining the part that supports the guides $2\frac{1}{16}$ inches below the center of the stuffingbox is done on the slotter. The true center of the stuffingbox is first obtained on a wooden bridge with hermaphrodite calipers, and the surface gauge is then set to this center; next, the setting is reduced $2\frac{1}{16}$ inches and a line is scribed on each side of the extension.

The casting must first be set up level both ways. The cover is then marked off for drilling and the holes are drilled. Next, the joint is ground in and the cover is applied. The valve bushings are then well lubricated after all foreign matter has been removed from the steam chest, the valve is inserted from the front, and the valve stem is keyed temporarily to the crosshead. Owing to the chamfer on the bushing, but little trouble should be experienced in putting the valve in.

58. Lining Up Crosshead Guides.—A copy of the print of the valve-stem crosshead guides is shown in Fig. 29. Each guide consists of a lower wearing plate or strip that carries the weight of the crosshead, and a vertical part that prevents lateral movement. Between these parts one or more liners are placed that can be added to or taken from as the crosshead or guide wears. These liners are rarely disturbed, except in the back shop or main roundhouse.

The guides, which have been machined according to the print, are now clamped loosely in place against the crosshead. They are lined up by moving the crosshead back and forth and at the same time adjusting them until they fit snugly without binding. They are then clamped tightly, the holes are drilled and reamed, the bolts after being fitted properly are driven in and tightened up. Many shops line up the guides in this manner before allowing them to leave the machine shop. The work is done in

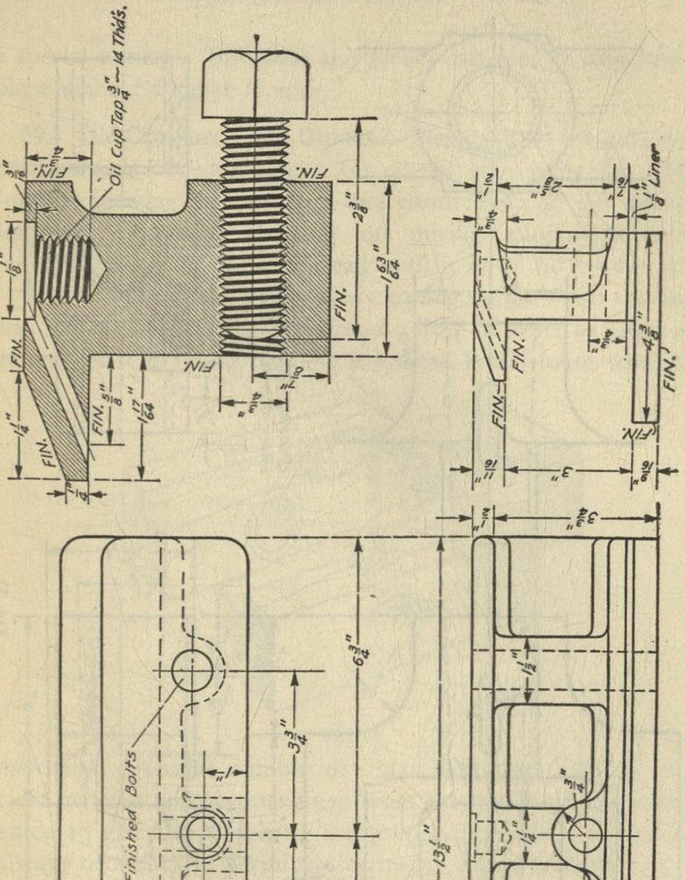
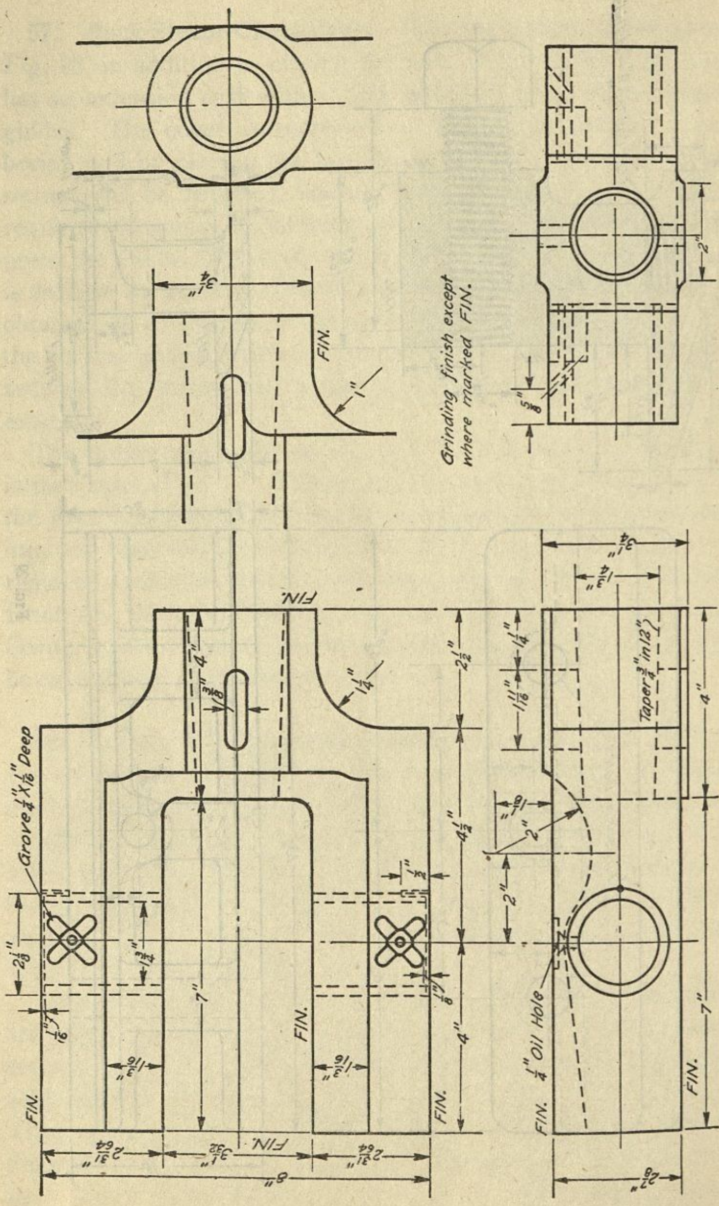

Oil Cup Tap 3/4"—14 Thds.
FIN.
3/16"
1/4"
1 1/8"
FIN.
1 1/4"
1/4"
FIN. 5/8"
1 17/64"
FIN.
3/4"
7/8"
FIN.
2 3/8"
1 63/64"
FIN.
1/2"
3/4"
2 5/8"
7/16"
1/8" Liner
3/4"
4 3/8"
FIN.
FIN.
FIN.
11/16"
3"
9/16"
1/2"
3 3/4"
7/8" Finished Bolts
1"
1/4"
3 3/4"
3 3/4"
6 3/4"
6 3/4"
13 1/2"
1 1/2"
3/4"
1/4"
7/8"
1 1/2"
4 1/4"

Fig. 29



Grinding finish except where marked FIN.

FIG. 30

a special fixture. The head and guides can then be mounted in place without further trouble.

59. Old Crosshead and Guides.—The work on the old crosshead consists of examining it for cracks, examining the socket for fit, renewing the bushings, and cleaning up all the wearing surfaces. Continual cleaning up during shoppings finally reduces the size of the crosshead until it is of no further use.

Work on old guides consists of cleaning up the worn surfaces, and this necessitates the removal of a liner in order to lower the guide. If it is found that the crosshead is too loose when the maximum allowable number of liners have been applied, sufficient material must be machined from the bottom of the vertical guide to give the crosshead the proper clearance. Liners are always necessary to permit adjustments between shoppings.

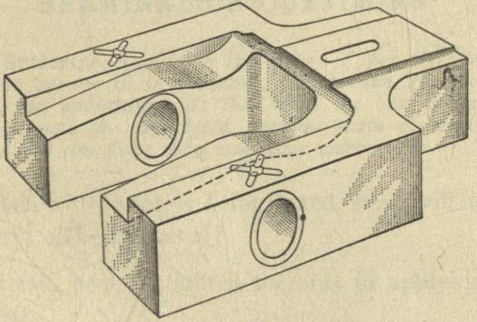


FIG. 31

60. New Crosshead.—The valve-stem crosshead is generally made of cast steel. The copy of the print of the crosshead under consideration is shown in Fig. 30 and a perspective is shown in Fig. 31. The same care is taken in laying off and machining the casting to make the valve-stem socket central between the vertical and the horizontal wearing surfaces as was taken when machining the large crosshead. Otherwise, it will be difficult to line up the guides properly.

The crosshead is bored out for two renewable bronze bushings that are turned and pressed in. The slot for the valve-stem key is drilled and milled to the dimensions shown on the drawing.

a special fixture. The head and guides can then be mounted in place without further trouble.

59. **Old Crosshead and Guides.**—The work on the old crosshead consists of examining it for cracks, examining the socket for fit, renewing the bushings, and cleaning up all the wearing surfaces. Continual cleaning up during shoppings finally reduces the size of the crosshead until it is of no further use. Work on old guides consists of cleaning up the worn surfaces, and this necessitates the removal of a liner in order to lower the guide. If it is found that the crosshead is too loose when the

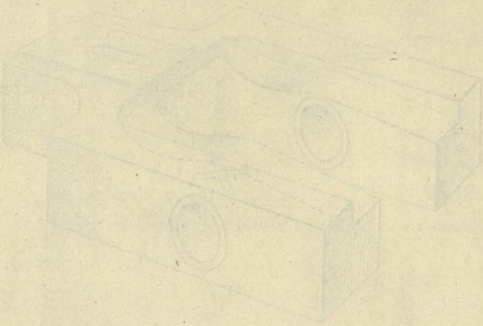


FIG. 31

maximum allowable number of liners have been applied, sufficient material must be machined from the bottom of the vertical guide to give the crosshead the proper clearance. Liners are always necessary to permit adjustments between shoppings.

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The crosshead is bored out for two renewable brass bushings that are turned and pressed in. The slot for the valve-stem keys is drilled and milled to the dimensions shown on the drawing.

CYLINDER, GUIDE, AND CROSSHEAD REPAIR WORK

Serial 2502 Edition 1

EXAMINATION QUESTIONS

Notice to Students.—*Study the Instruction Paper thoroughly before you attempt to answer these questions.* **Read each question carefully and be sure you understand it;** *then write the best answer you can. When your answers are completed, examine them closely and correct all the errors you can find; then mail your work to us.*

(1) When a cylinder is being bored, how will a spot that does not clean up be indicated?

(2) Explain how to tighten the nuts in applying the back cylinder head.

(3) What is the purpose of the guides?

(4) What does the term *lining up the guides* refer to?

(5) How is the boring bar set central in boring out a cylinder?

(6) Where will the greatest dimensions be found when a cylinder is being bored out?

(7) Of what material are the following parts composed: Piston rod; cylinder bushing; and the lining of crosshead shoes?

(8) How can the error be corrected if the port spacing of the steam-chest bushings do not check?

(9) In the alligator type of crosshead, how is the bottom guide lined up?

(10) Explain how to fit a snap piston ring.

(11) What are the disadvantages of one-piece piston rings?

(12) Why must the top guide be lined up first, with the Laird type of crosshead?

(13) Why must the piston rod have a taper fit in the piston and crosshead?

(14) Explain how to apply a snap piston ring.

(15) Explain how to apply Dunbar piston rings.

(16) How is the valve assembled?

(17) Explain how to fit the valve rings.

(18) What is the best method of locating cracks in piston rods, crossheads, etc.?

(19) How is a piston rod that has been working usually indicated?

(20) Why is it important to lubricate the cylinder before applying the piston?

Mail your work on this lesson as soon as you have finished it and looked it over carefully. DO NOT HOLD IT until another lesson is ready.

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